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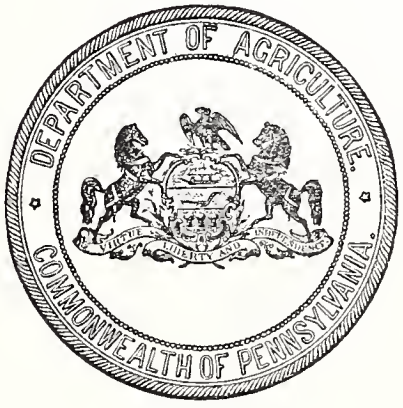
DEPARTMENT OF AGRICULTURE.

BULLETIN No. 105.

POTATO CULTURE.

BY

ALVA AGEE, Esq., Cheshire, Ohio.



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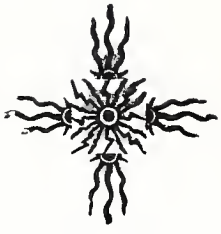

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PREFACE.

Harrisburg, Pa., October 20, 1902.

The following Bulletin No. 105, by Alva Agee, Esq., of Cheshire, Ohio, upon "Potato Culture," will interest farmers and market gardeners who are engaged in the production of this important crop. The discussion of this subject by Mr. Agee is from the standpoint of a successful potato grower, and not from that of a mere theorist. He uses the information derived from experiments conducted upon the Station farms of the United States, which throw light upon this subject, and at the same time calls attention to the effects that varying qualities of soil and character of climate have in modifying the statements of experimenters whose results have been secured under limited local conditions.

The bulletin is eminently practical, in the sense of bringing knowledge of the latest scientific facts relating to the habits and growth of the potato, to the aid of the farmer who is engaged in growing this crop, and in asserting so much only as he has personally tested and verified by many years of actual cultivation of this tuber.

JOHN HAMILTON,
Secretary of Agriculture.

LETTER OF TRANSMITTAL.

Cheshire, Ohio, October 20, 1902.

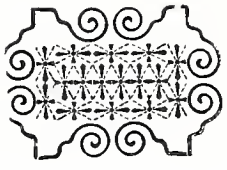
Hon. John Hamilton, *Secretary of Agriculture, Harrisburg, Pa.:*

Dear Sir: I have the honor to submit this treatise on the culture of the potato, prepared at your instance, for publication as a bulletin of your Department. It is based upon an experience of thirty years with this crop, the conclusions being influenced by many years' close study of the results in experimentation at the various agricultural stations. There is pleasure in noting the fact that the results obtained by our scientific experimenters, are in close accord with each other when the factors controlling these results are considered. In the matter of plant diseases and remedies, and in that of varieties, I have quoted freely from our best authorities, seeking thereby to gain the weight for the treatise that attaches to their names. While the grower of potatoes will recognize that the writing has been done by a practical farmer, I hope that it may be found scientific in that it contains truth arranged in an orderly manner.

There is no thought that a working plan has been outlined for every grower, but I have sought to make plain the nature of the potato plant in order that we might understand its needs, its likes and dislikes, and to indicate ways in which we might modify our local conditions. so that these needs would be supplied. When we understand the law governing the growth of any plant, and adapt our methods so that such law is not violated, success is assured with a fair degree of certainty.

Most respectfully yours,

ALVA AGEE.



POTATO CULTURE.

BY ALVA AGEE, *Cheshire, Ohio.*

During the eleven years from 1890 to 1900, inclusive, the potato growers of the United States produced over one thousand millions of dollars' worth of potatoes, valuing the crops at prices obtained upon the farm. The average yield per acre during these eleven years was less than seventy-seven bushels. The average receipts per acre at the farm were $34.57. If one-third of the present annual potato acreage were released to the production of clover or other profitable crop, and if the remaining two-thirds were given proper fertilization, seed and tillage, it would produce with ease 115 bushels per acre, worth $51.85. There would be no increase in total crop to depress prices, but there would be great increase in net profit per acre to the grower, and it is for this that we, as individuals, till our fields. There would be, in addition, the saving of nearly nine hundred thousand acres of good land from the annual potato acreage. Profit in agriculture must be sought in increased yields from a restricted acreage, permitting a greater percentage of arable land to lie in clover and pasture a sufficient portion of the time to guard its fertility.

This estimate of possible average yield per acre is made guardedly, and is well within bounds. Tens of thousands of growers would regard an average of 115 bushels per acre extremely low. It is an attainable average for our country, and would add many millions of dollars annually to our net profit from the crop.

PREPARING THE SOIL.

Potatoes are grown with a fair degree of success in many kinds of soil. The individual grower usually finds himself limited in choice, and may have nothing approaching a typical potato soil, which is deep, friable and retentive of moisture.

It is the desire of the writer to indicate ways by which fairly profitable yields may be secured from land that is not perfect in its adaptability to this crop, as it is so universally desired on our farms, either for home use or for market.

Physical Condition.—The first consideration in the selection of the potato field is the physical condition of the soil. That soil of the farm should be chosen which is naturally well drained, retentive of

moisture and sufficiently loose for the development of tubers, or which is capable of amendment in this respect. Experience and observation combine to convince me that the control of soil moisture is the great problem in farming, and it is true in an especial degree in respect to potato-growing.

Underdrainage.—If the land is naturally heavy and wet, underdrainage is required. There are few crops whose cash returns justify the expense of underdrainage in higher degree than the potato. If a soil would become fitted for this crop by drainage, the work can be safely advised, even for those who might find it necessary to borrow the money for the work. This is not the place for direction concerning drainage, but so many failures in potato-growing are due to an excess of water in the soil, that emphasis is placed upon the importance of underdraining any wet land that is to be given the costly seeding and tillage of the potato. The only first class material for underdrains is tile, and in most clayey sections of the country the yield of potatoes will increase with the extension of the use of drain tile.

Humus.—The control of moisture, however, is not secured in most soils merely by drainage. Deficiency in a supply at critical times in the growth of the plant is a usual cause of failure. In preparing a soil for potatoes, a leading aim should be to increase its capacity for storing moisture by the incorporation of rotted organic matter with it. The soil may be regarded as a big sponge for the holding of moisture, and its retentive character is fixed largely by its percentage of decayed vegetation. If a soil be clayey and deficient in humus, the water from rains runs off it or is evaporated from its surface, while the particles of clay adhere to each other, holding little water in a form friendly to plant growth. If a soil is sandy, the water from rains rapidly descends and passes away through the subsoil. Either class of soils is greatly benefited by the presence of decayed vegetation which stores moisture for future use of plants. Natural potato soils are rich in humus, and other soils must be made to approach them in character by the use of humus-making material.

The reader may have learned from excellent authorities that choice tubers are secured from land nearly free from humus, and it was formerly claimed by some that such land should be selected for this crop, but it was found that good yields could not be gotten in dry seasons without irrigation.

After six years experimentation with potatoes, the Cornell Experiment Station has reached this conclusion (Bulletin 196): "Where the soil is in proper physical condition the moisture may be conserved through an extreme drouth by means of frequent shallow surface tillage. But if the soil has become deficient in humus no amount of tillage is able to make good the deficiency.

"If all conditions are favorable as to rainfall and temperature, the humus problem is not so important, but if it is expected to carry a crop successfully through a season of extreme drought, as was the summer of 1900, the soil must be abundantly supplied with humus, or otherwise it will part with its moisture and the crop will suffer. Intensive tillage for best results through a series of years must be accompanied with the use of farm manures, or of green manuring. This is especially true of potatoes where best results are secured in a moist, cool soil. Abundance of humus favors both these conditions."

Rotted organic matter performs in the soil the double office of improving physical condition so that moisture may be held, air be admitted and plant roots be developed, and of furnishing plant food. Sources of such matter will be considered in their two-fold capacity.

Legumes.—Clover will fit land for potato-growing more completely than any other one plant within my knowledge. Its roots run deep and are bulky. Their habit of growth secures a fine division of clayey land, penetrating every cubic inch with fibres, and thus producing the physical condition of soil so grateful to the potato. We incline to look upon clover only as a fertilizing plant, and as such it stands pre-eminent in the sections adapted to its growth, but it is a safe statement that in a rotation of crops which includes clover and potatoes, the effect of clover upon the physical condition of the soil gives to this renovating crop half of its value. Such statement does not minimize its fertilizing value, which is unexcelled, but calls attention to another value in it often underrated.

As a purveyor of plant food, clover is first among plants. It feeds upon the free nitrogen of the air through bacteria that live upon its roots and serve it while living upon it, and through deep-running roots the clover feeds in the sub-soil where there usually is a great wealth of fertility. But clover has a way of failing. Or we may have lacked foresight, and there is not time to grow the clover before a crop of potatoes is wanted from a certain field.

There are other legumes of great value. Living near the southern border of our northern States, the writer has found it profitable to grow many acres of cow peas for plowing down for potatoes. The southern pea has its northern limitations, failing to make as luxuriant growth north of the fortieth parallel of latitude as it does in the friendly heat of the south. But it makes a good root growth and a fair amount of vine that give a rich humus, and it adds to the supply of soil nitrogen after the manner of clover. The soja bean is another renovating crop of value, growing quickly and providing a good supply of humus.

Other Sods.—A timothy sod will give good results when handled intelligently. Bearing in mind the need of the potato plant for thoroughly rotted organic matter, we may see that timothy can be made

to serve if plowed early. When the planting is to be done in early spring a timothy sod should be broken the preceding fall, and loss from winter exposure may be prevented by a seeding to rye. No inconsiderable amount of potatoes is grown in the farm and village garden and truck patch that have no proper rotation of crops, and such land always should have its winter cover crop of rye, crimson clover, rape or other similar growth.

Stable Manure.—The use of stable manure on potato land is very universally condemned by writers. When we view the ill effects only, the condemnation appears none too severe; but there is another side to the question demanding consideration. Fresh stable manure in the soil favors diseases that roughen the skin of the tubers. Our city markets bear evidence of the wide prevalence of soil diseases that reduce the value of crops, and it is the tendency of such diseases to increase and finally to cripple most seriously the industry of potato-growing. In view of this, the safe thing has seemed to be to discountenance all use of stable manure—especially that of the horse—on potatoes. But the writer shares the common experience of a host of growers that an application of farm manure, properly made, increases the net profit from potato fields, and we stop here to sift the matter for the sake of truth.

Going back to the fact that the potato wants its organic matter thoroughly rotted, we understand the good results gotten from potatoes after corn when the sod for corn has been sufficiently well manured to supply the soil for two years. The tubers are clean and thin-skinned, excelling in appearance the crop gotten where fresh organic matter abounds. It is right, then, to use manure on a crop preceding potatoes rather than upon potatoes, but the supply must be equal to the demands of the two crops, and if the first be corn, as is a common custom in some districts, that means a large supply. But I keep in mind, in this writing, the circumstances of a large class that either have land in limited amount or have manure in small supply, and are led by necessity to the planting of potatoes in land not perfectly fitted. With them the question is not what they would choose to secure perfection of conditions but what they may do to make the best of their situation. If land is lacking in physical condition, having had too heavy draft upon its supply of humus, and withal is to be planted with potatoes, it is usually wise to use a dressing of stable manure. This manure should be applied in the fall, and the best results are gotten from plowing it under to a depth of four or five inches before the middle of September in order that a winter-cover crop, like rye, may be seeded. In the spring the cover crop should be plowed down, the ground being broken deeply, and then the manure with its leachings is brought toward the surface and well distributed throughout the soil. The manure brings humus and fertility, and the soil lacking these should have the

manure even at the risk of the introduction of disease. It were far better if all land could be cared for properly, receiving its plant food and physical amendments at correct times in a wise rotation, but such conditions will never prevail universally, and hence the necessity of modification of methods outlined for perfect conditions.

Commercial Fertilizers.—A discussion of sources of organic material for improvement of soils before planting leads naturally to the subject of commercial fertilizers, and as the practical man should plan his work ahead of the plow, we discuss further the subject of fertilization before considering that part of preparation for a crop that is done with plows and harrows.

There are two methods of employing commercial fertilizers in common use. One of these is based on the belief that such fertilizers can be used profitably only in starting a crop, and preferably those crops with which seedings to grass are made. The other method involves the use of large quantities of commercial fertilizers for the constant feeding of the plants from seed-time till harvest. I forego the pleasure of a discussion of this important question except so far as it concerns the potato. Keeping in mind the necessity of net profit from the crop, we must secure all needed plant food as cheaply as possible. Most soils devoted to potato-growing, excepting now the seaboard sands that produce the early market crop, are naturally strong. That is to say, in them are stored large amounts of plant food that become available slowly. The average arable soil is a store-house of inert elements of plant food. Availability is secured in part through the growth and decomposition of crops like clover, peas, vetches, timothy, rye, etc., and the legumes also add nitrogen from the air. If a light application of commercial fertilizer of any sort will put clover or peas to work to supply the needs of a subsequent cash crop, such fertilization is rational and profitable. Such is the scheme of a majority of farmers, though its successful operation is not always apparent. There is failure oftentimes to get the full manurial crop or heavy sod, and the remaining crops of the rotation, dependent largely upon that crop or sod, are too small for best profit.

The other method involves the feeding of every crop according to its supposed needs, and necessitates an expenditure of money that a majority of farmers, selling in average local markets, would regard, possibly with reason, as ruinous. But the potato, grown near good markets, more nearly justifies such feeding than do most staple crops. Its possibilities far exceed those of the staple grains, and usually it is quickly responsive to fertilizers.

Scientists have sought a rule of universal application for the use of fertilizers. It was believed for many years that the composition of the soil, as shown by an analysis, would indicate the kind of fertilizer that should be used, but the theory would not stand the test

of practice. There are soils so deficient in some one element of plant food that safe inferences concerning fertilization may be drawn from the results of analysis, but these are not the common arable soils of the country. The chances always are that a chemical analysis would not prove helpful to a farmer. It probably would show the presence of a large amount of every element of plant food, and there information would cease. In practice one may know that the soil is lacking in available fertility, while nothing in the results of analysis would indicate such a fact.

Another scheme of fertilization was based upon the composition of the crop to be produced. The number of pounds of nitrogen, phosphoric acid and potash in a ton of potatoes is known, and it appeared reasonable that a fertilizer should approach the composition of the crop desired. This theory of fertilization is now discredited by leading scientists and by practical farmers, for two reasons: First, it fails to take into account the tons of available plant food in the soil. Land that has been given a heavy growth of clover, or a dressing of stable manure, may contain all the available nitrogen needed for the production of a full crop, while there is lack of potash or of phosphoric acid. The soil may be naturally so rich in potash that a score of crops would not exhaust the supply appreciably, and yet be lacking in available nitrogen or phosphoric acid—a lack not apparent from analysis of the soil, but apparent from results obtained when one of these elements is supplied to the growing plant.

The other reason for discrediting this theory is the rather awkward fact that experimentation shows profitable results from the seemingly excessive use of certain elements under some circumstances. A soil may be in fairly productive condition, and then give more net profit from a crop treated with twice the amount of one element found in the composition of that crop than it would from a lighter application, and at the same time another element may not increase yields at all. These puzzling results do not destroy our faith in the value of scientific investigation, but they assure us that the laws governing plant growth are not within our grasp in such degree that we can feed crops by any general formula prepared by others with assurance that we are doing the most profitable thing for ourselves. After turning to one and to another, we finally must depend upon ourselves and our own experimentation.

Station Results.—I state the matter of self-dependence thus because many are loth to give up the hope that others can save them from the trouble of farm experiments. They should understand that, so far as scientific research has gone, there is no way to know absolutely what fertilizers will pay best on a potato crop, or other crop, except by farm tests. And yet there are certain wide lines, fixed by Station results, within which we may confine our labors, and thus keep the chance of failure down to a minimum.

It is an old belief of growers that the potato is, in a peculiar degree, a feeder upon potash. It resulted that all special potato fertilizers a decade ago made potash the most prominent element. There is a reason for most things under the sun, and, in casting about for the cause of this confidence that the potato wanted potash chiefly, I am led to think that it arises in part from the known lack of potash in most sandy soils which have been devoted to potato-growing. On these soils applications of potash have been effective. It is further true that the ash of the potato is rich in potash, but in no higher degree than is the ash of some other crops. The New York Experiment Station, at Geneva, after a six years series of fertilizer experiments with potatoes, concludes that "this crop is not greatly unlike many others, including roots and forage crops, in its fertilizer requirements under given conditions."

It is known that sandy soils incline to be deficient in potash, and extensive growers of potatoes in such soils of Long Island, New York, use potash freely, having in common use a formula calling for four per cent. of nitrogen, eight per cent. of phosphoric acid and ten per cent. of potash. The correctness of this so-called Long Island formula naturally would be accepted for land of that class by reason of its general use were it not for the results gotten in the series of tests made by the Geneva Station under direction of Dr. Jordan. Very strangely the potash was wholly ineffective in some of these tests, and Dr. Jordan says: "The outcome of extensive experiments for four years on four farms presents good reasons for questioning the wisdom, under the condition involved, of applying more potash on potatoes than any other ingredient. It is now a trite saying, but a true one, that each farmer must discover for himself the fertilizer needs of his farm."

Nitrogen.—Within certain lines we may infer pretty safely the nitrogen requirements of our potato soils. Land that is very rich in humus, such as much black alluvial soil, is rich in nitrogen. This element is the most costly one in a fertilizer, and an unnecessary application cuts net profits rapidly. Stable manure, made on cement or tight clay floors, and kept without waste until spread upon the land, is rich in nitrogen. Where a soil is liberally fed with stable manure the year previous to the planting of potatoes, we infer that the need of purchased nitrogen is slight. The presence of a good growth of any of the legumes is assurance of the presence of this element. In a soil rich in humus the clover may feed largely upon soil nitrogen, while under other circumstances it may get a goodly share of its supply from the air, but in either case the nitrogen is at hand if the clover or peas is present, and the percentage of nitrogen in the commercial fertilizer may be kept small under ordinary conditions.

Again, we learn to determine the content of nitrogen in a soil by

the character of the growth. This element gives a rank growth of potato vines of a dark green color. Where the vines grow rank without application of nitrogenous fertilizers, we cannot hope to increase yields to any profitable extent by their use. Indeed, there is always danger of diminished yields as a result of excessive use of this element. This is frequently observable in old barn lots and in other spots that have had the leachings of manure. The vines grow to extraordinary size, while the tubers are very small at digging time. It may not be possible to state with certainty the cause of this phenomenon, but it has been supposed that the potato will not divert its energy to the development of tubers until the vines have reached a stage that permits the storage of some energy for this purpose, and where there is a quality in the soil inciting to extreme growth of vine, that stage of development favorable to forming tubers is reached too late in the season for good results. Be that as it may, the known fact that injury may result from the presence of an excessive quantity of nitrogen in the soil is all that the practical grower needs to place him on his guard. It is safe to say, however, that most cultivated soils incline to be deficient in this element unless stable manure or the legumes is used, and the question with the grower often is not whether nitrogen could increase yields, but whether it would do so with profit, or in what quantities could it be used in view of its costliness.

For Early Potatoes.—The nitrogen of the soil does not enter available forms rapidly in cool or dry weather. The grower of potatoes for early market usually finds it profitable to supply an available form of it to his early-planted crop to force growth before there is sufficient heat in the soil to convert its own nitrogen into forms required by plants. For this purpose the nitrate of soda is a common source. It is quickly available in the soil, and I prefer not to use it until the plants appear above ground, as the fertilizer will leach away if there are no plant roots ready to appropriate it. Slower organic forms of this element, such as tankage, dried blood, fish, etc., are desirable carriers of nitrogen for use of plants in mid-summer when decay is rapid on account of heat. It is suggested that one-third of the nitrogen be supplied in nitrate of soda, and two-thirds in dried blood, fish or other organic forms.

Nitrogen exists in unstable forms, and cannot be stored in the soil indefinitely. It wastes rapidly in the summer if no plant roots are ready to use it. If a potato-grower finds that he can use purchased nitrogen with profit, as is eminently true in the seaboard sands devoted to the early crop, it is advisable to provide part of the supply in organic forms that yield up plant food through decay as the season progresses, and to supply some immediately available nitrogen, in nitrate form, as a top-dressing during the late spring months.

Phosphoric Acid.—It is an admitted fact that most soils are relatively poor in phosphorus. Of the ten or more elements known as distinctly soil elements used by plants for making growth, only three are ever found deficient in most agricultural soils. Two only may be lacking, and oftentimes only one element. In considering the matter of fertilizing land for potatoes, I have tried to show that purchased nitrogen may pay, and it may not. Concerning this we judge by the character of growth the soil makes, and by field tests. Likewise, potash may or may not be lacking in available form. Concerning the third one of these three elements, phosphoric acid, the same may be said, but we assume that in nine soils out of every ten, if any one of these three elements is lacking, that one is phosphoric acid. If two elements are wanted, phosphoric acid will prove to be one of these two. The content of this element in the potato is small, and there remains a general impression that phosphoric acid is of minor importance in fertilization for potatoes, but a careful study of all Experiment Station tests is convincing that phosphoric acid cannot be left out of any potato fertilizer, and that the requirements for this element are wholly out of proportion to the amount actually stored in the tops and tubers of the plants. So pronounced is this that some careful experimenters have been led to say that phosphoric acid is the controlling element in a potato fertilizer. A formula for a fertilizer carrying the elements in the proportion found in the potato tuber would require four and one-half per cent. of nitrogen, two of phosphoric acid and ten of potash.

The Long Island growers have raised the percentage of phosphoric acid to 8, cutting the nitrogen to 4, and Station experimentation indicates that the formula should show a still higher percentage of phosphorus, while the potash may be cut down. The whole matter of fertilization must be left within wide lines, and the individual grower must find by farm experiment just what plant food may be given with profit to his land, but the assumption should be that any potato fertilizer should be strong in phosphoric acid. Until the opposite is proved true in the field, I should assume that this element should be the dominant one in the potato fertilizer used. The assumption is based not only upon Station experiments in sands as well as clays, but also upon the trend of opinion among those growers who test these things for themselves.

Let no reader get the impression that cropping should be done with phosphoric acid alone. Much land is being ruined to-day by such practice. But if he is a grower of potatoes he may begin experimentation with the fact that if any one element is lacking in his soil, this one probably is so lacking. Then he must learn whether he is supplying sufficient nitrogen through manures and clovers, and he must take stock of his supply of available potash in the soil, and sup

ply a need of that element, if such need exists, as is very often the case, notably with sandy soils.

Carriers of Potash.—The cheapest carrier of potash for most potato-growers is the muriate. It is a common impression that this material affects the quality of the tubers adversely, and the rather more costly sulphate is advised. In my own fields I have made some tests, selecting tubers from hills treated with the muriate, and other tubers from hills on an adjoining plat untreated, and having them cooked together under proper conditions. So far I have been unable to detect the slightest injury to edible quality from use of potash in the form of a muriate, and this has led to the study of Experiment Station tests with the result that the character of soil or season appears to be a determining factor. There is less assurance of the slightest injury to the quality of the potato from use of the muriate than would be expected from the importance that has been attached to the matter by writers. It appears that in some soils quality is affected, at least, when the potash is not applied before the planting so that the salt may be washed out by rains. In other soils there are no ill results. It is a matter easy of test for the grower, as both sulphate and muriate forms are on the market everywhere. Kainit, a low-grade sulphate form, contains so big a percentage of salt that it should be classed with the muriate in effect upon quality.

In respect to effect upon yield, it is probable that the more costly sulphate is the cheaper source of plant food for acid soils, while the muriate is most satisfactory for all other soils. The Rhode Island Station has arrived at this conclusion from the study of its own results in comparison with those of other Stations.

Ashes.—An application of hard-wood ashes usually has a favorable effect upon the yield of potatoes. As such ashes are rich in potash, this effect is doubtless one cause of the very common belief that potash is peculiarly a potato fertilizer. The truth is that ashes exert an effect upon most crops wholly out of proportion to their potash content, and therefore attributable to some other element or elements in the ashes. It is known that the lime in ashes is in an especially effective form, exerting much influence upon the soil. While, as has been stated, hard-wood ashes affect yields favorably, they promote diseases that roughen the skin of the potato, and their use is not advised except on acid soils. In some soils they also have an unfavorable effect upon the texture of the land.

Coal ashes contain practically no fertilizing qualities, but I have found that it pays to draw and spread the home supply on the more clayey parts of the potato land for its improvement in physical condition. They should be spread before the harrow, and worked into the surface soil.

Plowing the Ground.—Soils in which potatoes may be grown with profit vary so much in character and in location that no hard and

fast rules can be laid down. But keeping in mind the nature of the plant and its likings, we may make our practice conform to its needs. The first consideration, as has been said, is that of soil moisture. We want conditions under which a supply may be held for times of drouth. One method of securing this is by deep plowing. The storage capacity of land is increased by deepening the soil, as that is the part of the earth that contains organic material in such form that moisture is held as in a sponge. The deeper we plow, the more soil we have of such texture that the water of rains is received and held, provided the percentage of humus is maintained by increasing the supply as we increase the number of cubic inches of soil upturned by the plow. Within certain bounds we may make this rule for our guidance: The depth of plowing should be proportionate to the percentage of humus. But the potato requires an abundance of this material, and if our soil is properly stocked with it, the plow should go deep. Depth in plowing is a relative term. I know successful growers on land that will not permit a greater depth than six inches. They feed that six inches well, and make money. Preferably, however, the plowing should be deeper. Where six inches is a normal depth, seven should be gotten if possible. Where eight inches is a usual depth, nine inches should be sought.

Kind of Plowing.—I like the rule given above respecting the depth of plowing. If a thin sod be buried deeply, and soil deficient in humus be placed at the depth the tubers shall form, a clayey soil will give disappointing results. Worst of all, a layer of soil deficient in humus, either in clays or sands, is utterly unfit material for the soil mulch that we make at the surface by tillage for the retention of moisture. If the amount of organic material be small, it should not be distributed throughout too many inches of soil by very deep plowing. It is better to sacrifice the benefits of depth under such circumstances to insure fair texture of the soil in which the tubers form and of that at the surface. This caution is for those only who from necessity plant land not well fitted for potato-growing. Where the soil is supplied with such a store of humus as the potato delights in, depth should be secured by deep plowing. It was Benjamin Franklin who said, "Plow deep while the sluggard sleeps," and while the advice is much quoted and is wise within proper bounds, I venture the opinion that if the revered author were to return to earth and note the decrease in the humus-content of our American soils he would modify the statement so far as to say that the depth should increase only with increase of humus-producing material added in sods and manure.

The Plow.—There are breaking-plows of many models. In respect to the kind needed for turning sod land for potatoes, let us reason the matter out. Assuming that the soil needs the improvement in

texture due to rotting sods, we may be sure that the best of the sod should not be buried in the bottom of the furrow. There is more talk than practice of leaving the furrow-slices on edge. This is due to the use of plows having long and curved mold-boards, and to our liking for a smooth appearance in a plowed field. The sod should be left in such position for potatoes that it can be distributed throughout the soil, a fair proportion remaining near the surface. This means the leaving of the furrow-slice on edge, and that is done only by the plow having a short and straight mold-board. This point is not appreciated by growers who have a soil naturally loose and able to remain in good physical condition without the aid of organic matter, but such soils are the exception. The short and relatively straight mold-board leaves the furrow-slice as required by the potato in ground of rather poor texture. It will not pulverize while turning the ground as does the long, curved mold-board, but that is merely one of the drawbacks of farming a soil not perfect in its adaptability to a desired crop. The plow should be set to run true on the bottom, and to turn not more than an inch in excess of what is actually cut by the point.

Thoroughness in plowing is more important for the potato than for either corn or wheat, necessary as the latter may be. The potato makes in the ground, and is more dependent upon good soil conditions than is any of the cereals. If the workman will set the plow to cut a trifle scantily and then hold against the plow-handle to offset this, the furrow-slice can be partially pulverized with a very short, straight mold-board.

Time of Plowing.—It is probable that four out of every five of my readers plant early varieties of potatoes, or else plant medium varieties early in the season. They have doubtless observed that early-plowed land retains moisture more perfectly than land plowed later in the spring. Recalling the fact that drouth is usually a factor in cutting yields of potatoes, and that the control of moisture is the first consideration, we learn that it is wise to plow early for this crop. There is less loss of soil moisture from the airing given by plowing, and there is more opportunity for spring rains to restore the close union of the top soil and sub-soil so that water may rise from below. Much as we value an addition of vegetable matter to the soil, we do not want plowing delayed until a growth of clover or rye becomes bulky and woody, as experience teaches that this bulk has robbed the ground of moisture in its growth and interferes with the rise of moisture from the sub-soil when plowed down. Early spring plowing is advisable for most land devoted to potatoes that are matured before the first of September.

Fall-Plowing.—Regarding only soil fertility, land should be kept covered by a growing crop. Bare land is losing available plant food whenever it is not locked up by frost. Hence the condemnation of

fall-plowing for a spring crop. But we do not invest money in land primarily to maintain its fertility, but we maintain fertility in order that we may make money. Income must be considered. There is land of such texture that a spring-planted crop can not be produced from it in profitable amount unless it undergo the ameliorating effect of hard freezing. It cannot be put into fine physical condition after spring-plowing, while it does yield itself well to tillage when plowed in the fall and left frost-locked during winter. I am acquainted with some such land that is made to produce potatoes profitably for its local markets, and am sure that there is a serious mistake in condemning fall-plowing for it. Again, there is land now yielding good income from extra early potatoes that could not be plowed in time for the early planting if the work was delayed till spring. It loses some in fertility, but amends are made to it by the application of plant food easily purchased from the proceeds of its crops. When consistent with returns from the crop, land should not be left bare during winter. The losses from this source have been heavy in American agriculture, but there are conditions justifying some fall-plowing for potatoes, and the matter is one worthy of careful study. If seemingly best, do it, but remember that when bare and unfrozen, there is a loss of fertility that must be made good before net profit is figured.

Harrowing.—Potato land should be made fine, but not too firm. Spring rains tend to pack ground unduly for potatoes unless it is naturally very friable. The perfect harrow would be one that pulverizes each furrow-slice fast as turned, with power gotten from a horse walking on the solid bottom of the furrow by its side. I have tried to interest inventors in such a harrow, but am assured that too many farmers are indifferent to perfect work to make the demand for such a harrow attractive to a manufacturer. As it is, we plow land to make it loose, and then tramp it with horses while fining it until a considerable percentage of the soil is packed down as tight as it was before the breaking-plow was used. When the weight of a horse is placed on the few square inches of surface covered by his foot, the ground under the foot is packed. This is especially true of soil that necessarily is worked in the spring as soon as it crumbles nicely. The track of the horse fills with loose soil, hiding the damage done, but let the farmer remove the loose soil and dig into the ground that was packed by the pressure, and he will realize what is being done. It has been my rule to cut the plowed land with a twenty-inch disk harrow, drawn by three horses. Two cuttings, each lapping half, equal to four single cuttings, have been given to tear the sod into pieces. These were followed by an Acme, and then by a plank float. An estimate of the amount of surface covered by the feet of the horses in all this work is astounding. It may be thought that the harrows repair the damage, but usually they conceal rather

than mend it. In a fresh-plowed field the effect of the pressure given by the feet of the team goes much deeper than the average harrow. Indeed, thorough as my own harrowing has been, I find the firmed soil below the depth made by the extra large disks. Such pressure immediately under a hill cannot fail to do harm.

This consideration enforces the necessity of letting a soil become fairly dry in the spring before the harrow goes upon it. It also leads one to defer some of the preparation of the land until after the planting when the horses can be kept in the middles between the rows. This suggestion is made with some misgivings, knowing the tendency to slight preparation of a seed-bed, and the inclination to promise land additional work that is never given it. But I write of preparing land for an early crop, when rains are sure to firm the plowed ground sufficiently to put the sub-soil into close contact with it so that moisture can rise from below. A later-plowed field must be harrowed with thoroughness and made reasonably firm to insure against drouth, and at a later period in the spring the tramping by teams does not pack a soil so severely. But no matter how early the planting, there should be sufficient harrowing to make a soil fine. After the planting, a deep, thorough tillage can be given to complete the work of preparation. This will be discussed under another head.

It is always a mistake to plant potatoes among clods. The work of fitting with harrow and float must be sufficient to give to the piece of seed a surrounding of fine soil. The use of the plank float right after the plow, and again after the harrow, will do much to insure this state of fineness. There is no question in regard to the necessity of this much work. Some deeper tillage, however, may be deferred, provided one understands the need of it, and will give it before the young plants have sent their roots out into the soil.

THE SEED.

Success in potato-growing is dependent largely upon the seed. A large percentage of failures is attributable directly to the character of the seed. While I base what I write upon the experience gotten year after year in the culture of this crop, and upon the experiences of others, it cannot be expected that some readers will accept readily many of the statements, and to all such the request is made, in the interest of truth and their own income, that they put the doubted statements to the test of field trial. Many a farmer says that potatoes cannot be grown profitably on his farm when the fault lies with the seed he has been using, and the easy trial of good seed is within his reach. There are large areas that will not grow potatoes

well, and are not needed in the country's production, but most farmers should grow their home supply, and do it with some profit. This may demand a different fitting of the soil than that given heretofore, but to poor seed is many a failure attributable.

What is Good Seed?—The tuber of the potato is not the true seed of the plant; that is in the seed ball. Neither is it the root of the plant, as is the case with the sweet potato. It is merely an enlargement of an underground stem. The plant puts forth branches above ground which form blossoms, and at a certain stage of growth the plant puts forth branches, or stems, that do not come above ground and blossom, but remain below the surface, enlarge at the ends, and form that which corresponds to the blossom of the branch above ground, with the addition of starchy material stored about the cells leading to the buds, which is intended by nature for the feeding of the young plants when they are started another season. These buds, cells and stored starchy material, wrapped up in one package, is the tuber for which we cultivate the plant.

Just so sure as like produces like in this world, the tuber partakes of the nature of the vine that produces it. If that vine has grown in a heat that weakened it, or has been affected by disease or insects that lessened vigor, the tubers have a correspondingly low vitality. As we know, the potato thrives best in a cool climate. Excepting the high mountain elevations, all land south of the fortieth parallel has too much heat during some period of the growing season in normal years for the best development of the early-planted potato. It does not follow that big yields per acre are not obtained some seasons in the heart of the belt liked by our heat-loving corn plant. Our southern States grow good fields of potatoes, and yet the fact remains that the big yields are most easily gotten in northern latitudes—in Maine, New York, Michigan and the northwest. There the potato thrives in the absence of extreme heat, and has great vitality, as the size of the tubers attest.

Potatoes grown year after year under unfavorable climatic or soil conditions, decrease in vitality, and the man who clings to such tubers for planting must reap what he sows. The vines lack vigor, and the underground stems, or tubers, lack in size. Excepting high altitudes in our mountain sections, there are no sections south of the States mentioned above where the vitality of potatoes is fully maintained, and I am very sure that it would pay growers to get seed from the north every second or third year when prices are apt to be low. This statement could be put stronger by me, as I find it profitable to get seed from more northerly sections every year. But even if a change were made every second or third year, there would be far less loss from inferior stands of plants. I refer now to all growers who plant in early spring There are conditions under which vi-

tality in comparatively warm latitudes may be maintained for a time by growing the seed in the cool weather of autumn, but the experience of many successful growers is corroborated by co-operative tests at the Vermont and Maryland Stations, in which the Vermont seed proved to be the better. The Missouri Station found Vermont and Wisconsin seed superior to that of Missouri, and in tests of Rhode Island and Maine seed, the latter proved the better.

Selection of Seed.—Growers have been puzzled by the contradictory evidence concerning the relative value of small potatoes for planting. Experiment Stations and individuals have gotten results from comparative tests of small and large seed that conflicted with results from other tests, and some farmers have concluded that there is no choice in size. Let us think over the matter. The tuber shares the degree of vitality possessed by the vine. It is a branch—only underground. Its size depends upon two things: the vitality of the vine and the time the tuber was formed. If it belongs to the second lot of setts made by the vine, and is small simply because it did not have time to become large before the vine matured, it comes of just as good stock as the larger tubers, of the first lot of setts, in the hill. It has good blood and can reproduce the vine that produced it. Such seed, though small, may give a maximum yield. But there is the small tuber that was part of a spindling vine, low in vitality. It is small because there was not enough good blood in that vine to make any tuber as large as it should be. It is low in vitality, as the vine was—a good-for-naught trifling—because the vine had no original vigor. There are two kinds of small potatoes. Those from vigorous vines may give good yields, while those from spindling vines are a disappointment unless highly fed by a rich soil under favoring climatic conditions. It could not be otherwise according to nature's laws, and it is not otherwise in our farm experience.

The Runty Potato.—Too much emphasis can hardly be placed upon the distinction between the tuber of small size that has been produced by a vigorous vine and the tuber of same size produced by a weak vine. In the former instance we have a potato—an underground stem or branch—that partakes of the great vitality of the plant as evidenced by the strong branches. It failed to attain large size because it belonged to the late setts of the plant, or because the plant was late and did not have time for full growth. The tuber of the other class is small on account of the natural weakness of the vine. When small potatoes, known by growers as "seconds," are used year after year in planting, the percentage of runty individuals increases rapidly. Nearly the entire product of the spindling hill falls into the "seconds" class. Let us suppose that in one season's planting there is only one degenerate vine in a hundred. That will not affect the yield perceptibly. Assuming that each one of the

ninety-nine vigorous vines furnishes one tuber of good vitality for the "seconds" class, and that the spindling vine furnishes five tubers, we have the next year five degenerates out of a hundred and four. The next season we may expect twenty or twenty-five out of a hundred.

As a matter of thirty years observation in a potato-producing district, this rate of degeneracy is not at all unusual in the case of careless growers. I have seen crops of thousands of bushels, produced from small seed taken from a crop grown from small seed, that ran so inferior in size that they were not wanted in market, while fields planted with seed of high vitality produced tubers of fine size. The seed was "run-out" through the continued use of "seconds." It is true that small tubers from spindling vines may not give a failure of crop when used for planting. It is possible to have a soil so rich and fine that high-feeding of the plants brings improvement of the stock. Equally, soil and climate may prevent deterioration of the stock when "seconds" only are used. Were it not for such possibilities in plant life, improvement of strains would be slower work than it now is. But most potato-growers are seeking net profit from their land, and very many do not have any excess of fertility. As practical men, they should see that vitality in seed is a prime requisite. The plant should come with vigor, not requiring superior fertility to give it courage to grow, but showing good hustling qualities when first it appears above ground, and ready to use to the full all the advantages that may be within reach. A vigorous plant will make a fair yield in moderate soil, and a better yield as opportunity is given it through applications of plant-food and through choice tillage.

Medium Large Seed, Best.—While a late sett of a vigorous vine, being a second in size, has the vitality of its parent vine and may give as big a yield as a larger tuber, in ordinary field culture the chances are against it. In the case of some varieties, planted in certain soils, one need not hesitate to use "seconds" from vigorous hills. Nine out of every ten of my readers will do best not to use "seconds" at all for planting. They will obtain, as a rule, finer crops from seed pieces cut from larger potatoes. Some tests will prove convincing, but a little study of the matter may be equally so. The material in the potato is intended by nature as food for the buds or sprouts until they have root systems, capable of supplying themselves from the store of plant food in the soil. A large piece of potato will feed an "eye" and push its growth more effectively than a small piece. There are small whole tubers that will send up only one or two sprouts. These belong to certain varieties, or else were produced from vines that never matured. These tubers have sufficient nourishment for the one or two sprouts sent above ground, and make de-

sirable seed. But most "seconds" used in planting push several buds, whether planted whole or cut into halves. They have more sprouts than they can feed vigorously. More than this, the number of plants in the hill is too great for the fertility of the soil. The soil of garden strength and tilth may take care of this excessive number of plants per acre, and push growth so that a fair proportion of the numerous setts will attain a good size. Some nearly maximum yields have been obtained in this way. But success was due not to the seed but the soil that was equal to the emergency. For the ordinary soil and season, the number of plants per acre should be limited by the use of seed pieces having a smaller number of eyes than do "seconds," whole or in halves.

Form of Seed.—The form of the tuber is modified by the soil and season. A crop of ill-shapen potatoes may be gotten from choice seed because the ground was hard and interfered with symmetrical development, or because the season caused growth to be checked and then to be resumed after a portion of the tuber had begun to mature. It follows that results from selection for form are not as satisfactory as those gotten from similar selection in the corn field.

But one should select a variety whose type is pleasing, and then select seed fairly true to type. This is entirely practical for a grower on a small scale, but in commercial growing there are obstacles. The season or soil may have affected form temporarily, or the potatoes brought from a northern point for growing may be too costly to permit culling for conformity to type. I find it profitable always to select for vigor, and there selection must end with many growers. By selection for vigor is meant the discarding of all tubers whose appearance does not warrant faith in their ability to make strong plants. The drawn appearance of the bud at the so-called stem or butt end of the tuber, the presence of weak buds just starting, or of little potatoes in the bud, the tendency in a round or semi-round variety to form a point at the tip end with undue number of eyes, a hard, brittle texture that causes the cutting-knife to work with difficulty, dark streaks or blotches under the skin—any one of these characteristics should condemn a tuber for planting. When a man plants one hundred acres or only one acre, it is impossible that he can afford not to exercise the care necessary to secure a stand of strong plants. Some large growers assume that such care is out of the question. They are planting extensively in rich soil and get good yields. While such is the case, they are not getting the yields they should secure so long as some hills are failures because they would not discard a worthless piece of seed and supply a vigorous piece. Every piece of worthless seed represents a failure to get a hill of marketable tubers. The man who is so rushed by work that he plants a piece of worthless seed knowingly because he

does not have time to discard it when cutting, or before, is planting too extensively for best net profit. If the value of a good hill of potatoes, when produced, is not equal to the cost of throwing out worthless tubers before planting, there is no money in the crop. Each seed piece represents a success or failure for a certain area of soil. The yields of fields are kept low largely by the failure of many hills to do a fair share of the work of production. Many hills in a field usually produce at a rate that would seem extraordinary to a grower, while vacant hills and spindling vines in others, reduce the average to a moderate yield per acre. When potatoes are drilled eighteen inches apart in rows thirty-four inches apart, there are over 10,000 hills per acre. A single potato in each hill weighing a pound, would give 166 bushels per acre. I am entirely aware of the misleading character of estimates based upon single hills or very limited areas, and equally am I aware of the practical impossibility of making each hill do its fair share, but such estimates as the foregoing have shown me the folly of using a seed piece that I knew could not make a vigorous vine. Often we do not know; the impaired vitality cannot be detected. Hence a degree of failure no matter how successful the crop. But it is indefensible carelessness to use any seed that does not appear vigorous.

The tubers that make abnormal development are not the safest seed. The buds often start weak. Experience teaches that it is wise to select tubers of medium size, unwasted by sprouting in storage, smooth as type will justify, and free from evidence of disease and degeneracy.

Southern Second-Crop Seed.—Twenty years ago the market for the potatoes of the producing sections along the Ohio river was found in the south. This was equally true for a portion of the New England crop, which was quoted in the market reports as "Boston Peerless." These potatoes were sold chiefly for planting, the south being dependent upon the north for seed, and when we rolled the barrels out upon the New Orleans levee after storage for many weeks in our flatboats, the sprouted, wilted condition of the potatoes made them present a sorry sight, but nothing better was available for our customers. In time the demand fell off, and we learned that the planters were using a later home-grown crop of the preceding year for spring planting. This was the so-called second-crop seed. Concerning this seed, Professor Massey, formerly of the North Carolina Station, says:

"About twenty-five years ago, by reason of an early and favorable spring, in northern Maryland, our early crop matured much earlier than usual. Many cullings were left in the ground, which we had intended to prepare for celery. But before we had an opportunity to do anything with it, we found so many volunteer potatoes coming that we concluded to let them grow. The

weeds were pulled and chopped out by hand, and in November we dug a fine crop of potatoes from these broadcast volunteers. We wrote to friends in southeast Virginia that there they could do this thing regularly, and from that time the growing of the second crop from seed of the first crop took its rise. Of late, parties about Louisville, Kentucky, have been claiming that the practice originated there, but we are not disposed to yield the claim to the origination of the idea. * * * * Our practice is to take the potatoes as soon as dug in June, clip off a thin shaving from the seed end, and then spread them in a single layer in any convenient place and cover them about an inch over the top with soil. The land is prepared for the late crop by running deep furrows, going twice in a furrow and cleaning it out. Then at any time, last of July and early August, as the bedded potatoes start sprouts, we plant the sprouted ones (and no others) without any further cutting, and cover very shallowly in the deep furrows. Planting continues until the middle of August, though, in some seasons, those that sprout later will make a crop, but the middle of August is usually as late as is safe. As the potatoes make green tops, the soil is worked into the furrows, until, finally, all is level. The cultivation is as level as possible, the object being to conserve moisture. If covered in full in the deep furrow at once, few of them would grow, but by gradually filling, we get the roots well down in the moist earth and then cultivate flat to keep all moisture there. The importance of this crop as a seed crop cannot be over-estimated. They are gradually making their way northward for spring planting, and as all who have tried them find the crop better and earlier than from the northern seed, market gardeners will be compelled to use them if they are to compete with their neighbors who do. In our own experiments here, we used second-crop seed raised from potatoes from New York and Maine, planted alongside of potatoes brought the second spring from the same stocks. The growth from the home raised seed was much more robust than from the northern seed, and when the potatoes were dug there was not a potato in the crop from the northern seed that would not have been classed as a culling in the crop from our home-grown seed. The late southern crop of potatoes, dug last of November or first of December, have not started a sprout when planting time comes here in February, and kept in a cool, dark cellar they will not start a sprout until after planting time north. They thus start with the full, strong growth of the terminal bud, and make a strong, erect main stem; while the northern potatoes, lying many months in cellar, have to have the sprouts rubbed off, and their growth when planted comes from a cluster of lateral buds and from a partly-exhausted food supply in the potato. The late southern grown crop is the coming seed crop for all parts of the country."

I began using this seed for northern planting about ten years ago, and find it fully equal to the best northern seed. It is preferable for early planting when small in size, as no cutting is required and a single stalk, as a rule, is sent above ground by the tuber. This insures vigor, limits the number of setts in the hill, and gives marketable size to the crop at the earliest possible date. When the second-crop tubers are small, as is the case when the planting is very late and frost arrests growth, a less number of bushels is required for planting an acre. New Jersey now grows an extensive second-crop, and my own planting of five acres this year with such second-crop Early Fortune seed was so satisfactory that there is inclination to emphasize the desirability of more extended use of the second-crop for northern planting. It is not urged, however, for the simple reason that there has been disappointment from receiving stock not true to name. This seed is wanted for an early market crop, and our growers have paid the usual high price, and given this seed the choicest early ground, only to find that the variety was a late one and unsuited to our conditions. Personally it has been found best to buy of an acquaintance among producers of this seed, and it is entirely hazardous to depend upon the representations of middlemen unknown to the buyer. At the Ohio Station the southern seed was not found superior to choice cold-storage seed of the north, but it is superior to the seed ordinarily used because it does not sprout and waste before spring, as is the case with northern potatoes in the southern portion of our potato belt.

Commendation of this southern seed may appear inconsistent with what has been said under another head, but it is not so. The small size is not objectionable for the reason that it is due not to lack of vitality but to arrest of growth by close of the season for growth, and for the reason that the small tuber, or the cut piece, does not put forth several sprouts, as is so commonly the habit of northern "seconds." So far as my observation goes, a single sprout from a seed piece is the rule, though two sprouts may not be unusual with some varieties. In respect to latitude, the second crop is grown so late in the season that the vines have as much vigor as northern potatoes growing in mid-summer. It is produced in cool weather. There is temptation to the southern producer to plant too early for sake of increased yield, and some years the tubers become very large and are matured. Such potatoes are less desirable for planting.

Immature Seed.—This second-crop potato, is, of course, immature when growth is stopped by frost. It is an old teaching that the use of immature seed is inadvisable. That able authority, Mr. E. S. Carman, has said: "All analogies point to the conclusions that immature tubers as well as immature cuttings of any kind, will produce comparatively feeble plants. This is well exemplified by the weakened

constitution of grape-vines grown from green wood." I am not in a position to affirm that continued use of immature seed will not diminish virility in the long run, and I have observed in New Jersey that the growers prefer Maine-grown stock for the first crop, from which seed is gotten for the mid-summer planting of the second crop. But it is an established fact that immature seed is desirable for a single planting. It does not evidence any lack in virility, and gives a better plant than matured seed as usually kept in our warm latitudes, because it has not lost by sprouting. The material in the cells that feed the eyes has not been broken down ready for starting a sprout before the desired time for use. So true is this that many northern growers of early-planted potatoes are learning to plant a strip very late so that the crop will hardly mature by frost, and to use this crop for the next season's planting.

Sprouted Seed.—Too much cannot be said against the use of badly sprouted seed potatoes. The material in the cells at the eyes gives a stronger bud than a second supply of material can give when the first bud is removed. The potato should be kept so cool that no buds will start until wanted. The keeping of seed will be discussed under another head. In the event that sprouts do start too early, they should be removed, and the seed should be budded in the light before planting. There is distinct loss when seed is permitted to waste by sprouting in bulk.

The Cutting.—There has been conflict in the teaching regarding the size to which the seed piece should be cut. Careful study of the results obtained at Experiment Stations and upon farms of commercial growers will show that results under like conditions do not conflict, and that a safe rule may be gotten for our guidance. For soils of average fertility and state of tilth, the larger the seed piece, the more vigorous the young plants, and the fewer the plants, the larger the tubers produced. It has been quite definitely demonstrated that a greater yield in case of most varieties can be gotten from a whole large potato used in planting a hill than from any less quantity of seed, but the increase may not be gotten with profit on account of the cost of the seed and the average size of the tubers grown. With most varieties the whole tuber will give more plants in the hill, and more setts, than is desirable. The proportion of small potatoes in the crop is made unduly large. The vigor of the vines may carry a sufficient number of the tubers to merchantable size to make the marketable crop equal to, or in excess of, the yield from a smaller amount of seed, but this is rarely done with profit. The concensus of the best opinions of experimenters is that whole, large tubers should not be used in planting.

The other extreme has been the planting of pieces cut to a single eye. Good results have been obtained from such planting. Revert-

ing to our rule laid down, the number of plants in the hill is kept small, favoring quality in the product of the hill. But for the single-eye cutting, when quite small, we must have the same soil conditions that we have found to give a good yield from seed of somewhat impaired vigor—one that is very rich in available plant food and that is in a fine state of cultivation. The small cutting does not contain much material for forcing growth, and the plant is quickly dependent upon the soil. If conditions are not highly favorable to the plant, there will be a smaller yield than would be gotten from more liberal seeding. The advantages are, reduced setting, which ordinarly is too free when plants are numerous, and reduced cost of seeding. There have been so many grievous disappointments from the use of single-eye cuttings in soil unfitted for such seeding that I recommend such only to the grower providing garden conditions, and even then only in case of certain varieties whose great fault is free setting of tubers.

The Middle Ground.—Basing the conclusion upon many years personal experience and upon the experience of many at Stations and upon farms, the safe course for the average grower of potatoes, planted in the spring, is to use a seed piece of good size, such as will ordinarily contain two strong buds. I regard the size of the seed piece rather than the number of eyes. If there be sufficient nourishment, a single eye, being a compound bud, may send out two sprouts: if there be three eyes on the seed piece and insufficient nourishment for three sprouts, it is very often the case that only two will be sent to the surface of the ground. A piece of potato of this size does not dry out as quickly as a smaller one, pushes growth more surely, and is not unduly expensive.

As has been said, much depends upon the variety and its habit of setting, and even more depends upon the tilth and strength of the soil. Good judgment is a decided acquisition in potato-growing, coming into profitable use at every step. Our endeavor only is to indicate the nature of the plant we grow, and the probabilities, based upon average conditions. As conditions vary, there must be variation in method to meet them.

Machines for cutting are used with satisfaction by many growers. My individual preference for the hand-knife is due to the greater degree of carefulness that can be exercised when cutting by hand. Bad tubers are more surely discovered, and there is adjustment of size according to position of the buds so that no piece is left without a bud.

Much has been written about the cells that lead to the buds, and the advisability of cutting each piece in such a way that the branch cells from the central one are not disturbed. This is done by holding the tuber in such position that the butt end is down, and start-

ing the blade slightly above the eye and cutting downward toward the center and butt end. The eyes of the potato are terminal buds of unseen "branches," and the aim of this method of cutting is to divide the potato without cutting a "branch" off near its bud. For single eye-cutting, the system works well with most varieties, and fairly well when cuttings are larger. There is no clear demonstration that yield is favorably affected. Probably as good a rule is to seek compactness in form of the seed piece.

Impotent Eyes.—In some varieties there is a tendency to form dormant eyes near the butt end, and this inclination is greater some seasons than others. The eyes nearest the butt end start more slowly than those near the tip end usually, and in many varieties the most vigorous sprouts are well confined to the two-thirds of the tuber having the tip end. In such cases regard should be paid to this fact in cutting, preferring that an eye from the middle of the tuber be joined with one near the butt end rather than that the piece be so shaped that it contain eyes from butt end alone. Where a tuber affords only four pieces, the old-fashioned method of quartering through the tip end is as good as any, if not better; but for large, long tubers I prefer clipping pieces off the butt end, if eyes are all right, until a size for four pieces is left, when it is quartered.

Clipping the Tip.—It is a common experiment with growers to clip the tip end off "seconds," the thought being that the eyes there are too numerous for proper nourishment of the sprouts. But Station experiments do not justify such cutting, showing no increase in yield. These eyes are often the earliest ones. It is very often the case that only one or two of them sends a sprout above ground, appropriating the strength of the seed piece. I prefer any eye that has been produced near this end of the potato to one produced equally near the other end. It is more sure to give a good account of itself.

Budding in Light.—The practice of starting the buds, or eyes, in the light before planting was introduced to secure earliness of crop for market or home use. Having had no extensive experience with this method, I quote the following description given in Bulletin 36 of the Rhode Island Station:

"The most desirable seed tubers for budding are those about the size of hen's eggs, sound and not mutilated in digging. They may be reserved for the purpose when digging the previous crop, and if allowed to become 'greened' by exposure to sunlight so much the better, or they may be selected from the bin at any time. During stormy days or at any convenient time during the winter these seed tubers can be placed in the trays and then stacked up anywhere in the cellar secure from rats and frost until wanted. The tray to be filled is placed upon a table or bench and one end elevated about a foot by placing a box or measure under

it. Then beginning at the lower side the potatoes selected as above are packed into the rack stem end down as closely as possible one layer deep. Tubers cut or pierced by the tines of a potato digger or fork should not be used, as they are likely to produce sickly or inferior buds.

"About six or eight weeks before planting time the rack should be placed in a warm and light place where there is no danger of frost or damage from rats or mice, and the trays placed in the rack. If the temperature is moderate—sixty degrees to seventy-five degrees—and a fair amount of light reaches all parts of each tray no further attention is necessary; they do not require watering. After a few days tiny white points will be seen at the 'eyes' of the tubers, and a few days later it will be noticed that one and often two buds on each tuber will have made more growth than the others. These buds are far different from the white, watery 'sprouts' of potatoes kept in a dark cellar. They are thick, firm and tough. If conditions are right, at the end of six weeks they will be from half an inch to an inch in length, and one-fourth to three-eighths of an inch in diameter, with many rudimentary roots at the base waiting for the moment when contact with mother earth shall enable them to burst forth and go about their work of gathering plant food. At the top of the bud are tiny rudimentary leaves also waiting to do their appointed work as soon as opportunity is offered. It is well to look at the trays each day, as, if the rack stands against a wall, it may be found that the buds at the back side of some of the trays where there is insufficient light have a tendency to grow long and white. In that case move the rack out from the wall and change the trays about so as to reverse their position. In such a case more light is what is required. If the buds are not developing rapidly enough give more heat, and if growing too fast or storms and frosts prolong the planting season beyond the usual time, give less or no heat and plenty of light. When budded ready for planting, they may be held without injury for days or even weeks by keeping the racks in a cool, light place.

"The preparation of the soil does not differ from the course usually followed in growing early potatoes. It should be deeply plowed, made mellow and filled with soluble plant food. For marking out the field, a small plow or some implement making an open furrow about six inches deep should be used. Some fertilizer should be thoroughly mixed with the soil at the bottom of the furrow which process will fill it up one or two inches. We are now ready to put in the tubers. The trays should be taken from the rack and carried to the field in a spring wagon so as not to break the buds by rough jolting. At the field the most convenient way is to place a rack on a wheel-barrow and run it along between the rows. Two persons can work together at setting the tubers, one on each side

of the barrow. Each should be provided with a thin-bladed knife and when a tuber has two good buds it is divided as equally as possible without injury to the buds and the pieces immediately and carefully placed in the bottom of the furrow, the buds pointing upward. When there is only a single well-developed bud the tuber is planted whole. Earth to cover them is drawn into the furrow with a hand-hoe."

Modified Method of Budding.—The description quoted is given on account of its value to the grower of extra early potatoes, and especially for the reason that a modification of this method has value for all growers. While earliness of maturity is sought by those using trays for budding, there is a big gain in the vigor of the plants. Not only is the time between planting and harvesting shortened, but yields are increased as a result of increased vigor of the vines. This makes the matter of budding interesting to all growers. It is not feasible to expose all seed to the light in trays and then to plant by hand, but we have learned that seed may be spread over the floors of barns, sheds, etc., for ten days or more before planting with good results. It is important that the tubers be spread very thin—one-deep is best—and that light be admitted freely. The buds push quickly and are thick and vigorous. The air makes the sprouts tough so that they do not break off in planting, and any bad seed can be thrown out. Such method is becoming common in sections practicing very late planting. The seed can be kept for weeks in late spring without injury when exposed to sunlight. If placed in a dark room, or if not turned occasionally, the sprouts grow white, tender and long, and break off when handled in planting. The secret of success in budding is to keep the potato in so much light that the sprout will not push out toward it, but will rest in it developing thickness and fitting itself for strong growth when the undeveloped roots at its base are given soil and moisture. This plan is suited to the needs of the late or June-planted crop. There is yet another modification of the system of budding that is adapted to the needs of the farmer who plants his crop in early spring, and it will be described under the head of "planting."

Varieties.—A glance at the results of variety tests at the various Stations impresses the truth that financial success or failure in potato-growing may be determined by the choice of variety. Growing under even conditions, one variety gives less than one-half the number of bushels per acre yielded by another variety. The soil may be right, the culture good and the seed in first class condition, but if the variety is not right, the yield will be relatively small. The varieties of potatoes are numbered by the hundreds in this country alone. Many of them never had sufficient value to justify their introduction, while some have peculiar fitness for the climatic and soil

conditions of limited areas and are valueless outside of those sections. There remain a few score of varieties that were decided acquisition, when put upon the market, and of these few score it is the individual grower's business to select the one or ones most valuable to him.

How they Originate.—Most new varieties are seedlings, though a few of our valuable ones are "sports" from old varieties, their characteristics having been fixed by careful selection. Seedlings are fairly easy to produce, but probably not one variety out of ten thousand secured proves actually to be worthy of introduction. The true seed of the potato is in the seed ball. The ball is dried, the seed is removed, and should be planted in early spring in pots. Transplanting in the earth is done when the weather becomes warm, and these plants produce tubers of many shapes and colors. Selection of the most promising ones is made, and each one should be planted by itself. If the crop from any one again gives promise of value, it is made the basis of a new variety whose characteristics are fixed by selection of tubers true to the type. Years are required to fix characteristics, and finally, when tested by the side of an old variety, it may prove inferior. It has cost time and money, and the temptation is to push it upon the market with extravagant claims of merit. These facts are not given for the discouragement of beginners in the work of developing new varieties. Within bounds it is a labor to be commended to the grower who has a little leisure and some taste for such work. There is always the chance of bringing into existence something of decided value that not only will add substantially to the wealth of the country, but also will make a good cash return to the introducer. It is a safe guess that varieties will be found in the future whose merit will exceed anything we have, and the men who produce them will serve the people as well as themselves individually. But the chances of failure are mentioned that we may be slow to invest in every novelty that is placed before the public. New varieties that are decided acquisitions, possessing a merit in higher degree than any other, are added very slowly to the list of safe varieties for planting.

How to Test.—There is a very general disposition on the part of farmers to give an extra chance to a new and costly variety they purpose testing. If the purpose is to find something of extra merit to take the place of a variety in use, the place to test is in the field under field conditions. If it cannot show superiority in a row side by side with the variety that is furnishing the income from the crop, it is a poor investment. It should have the same tillage, fertilization and, shall I say neglect, that are given to the general crop. If it then show superiority, it is worthy of another trial to indicate its action under other seasonal conditions. Rigid tests are the only ones

worthy of practical men who propose to use the results in deciding whether their chance of net profit from commercial potato-growing shall be placed in the keeping of a new variety or left to rest upon old varieties. The seed-grower has a different view-point. He is catering to the public demand, and when he believes that a new variety of potatoes is to receive a lot of booming from its introducer, it is his business to secure the most bushels possible from his limited and costly stock of seed in order that he may supply the calls upon him for this variety. It is given the best ground available, and no pains are spared.

Selecting Variety.—The grower should know his market and be governed in selection of varieties accordingly. City markets differ in their requirements. One will demand a long, white potato, and the demand is traceable to its liking for some old variety of that type which quite possibly has ceased to be produced. More productive, and usually less palatable, varieties of similar form have taken its place, and are sold by dealers under the old, well known name that is used by most consumers when ordering. Another city market demands a round potato for like reason. It does not pay a grower to try to educate a city market, and he does well to plant a variety of the general type in demand. In smaller markets the grower who disposes of his crop from his wagon, and has a regular custom, can introduce a new type of potato of superior merit with profit. Conditions determine what should be planted, and money has been lost by failure to study market requirements. Color is even more important than shape. It is a waste of time to attempt to convince a city market of the choice quality of a blue potato, however meritorious, when the people are accustomed to the sight of white or slightly pink varieties.

Limiting Demand.—The amount of potatoes consumed by the people is limited by the quality. Unfortunately many of the most prolific varieties are not high in table quality, and some of the most productive potato soils give tubers of poor flavor. The grower is mindful of net profit for the season, and plants the variety that promises the greatest return per acre. For this he is not to be condemned, but it results that millions of bushels of potatoes go on the market every season, limiting demand by reason of their poor edible quality. The consumer cannot discriminate when buying, and those who are unforunate in selection do not consume the amount they otherwise would use.

Some varieties are good keepers, and improve in quality as spring approaches. On the other hand, some of the choicest varieties deteriorate in quality rapidly by spring. Soils affect quality, and a "soggy" variety in one soil may be of high quality in another. Twenty-five years ago the Peerless was a watery potato with us, and yet

it was grown by the tens of thousands of bushels in our valley because it was the one variety most salable in our market—New Orleans—which was a depot for shipment of seed potatoes to the Gulf planters. The crop grown from the Peerless in the south suited the market, and our business was to supply the potatoes for planting, and to grow the variety wanted, adding a quarter of an acre of a more palatable variety for home use. There is a limited demand for a soggy potato from restaurants and hotels who want it for slicing. But a dry potato, bursting its jacket when boiled, and having a high flavor, is the one that helps to increase the popular demand for this vegetable.

Effect of Soil and Season.—Just as the prolificacy of a variety cannot be determined by a single test, so is a single season's test of table quality indecisive. Varieties vary with the season and soil. The highest quality in any variety is gotten in a year of rapid and constant growth. A check to growth from drouth, followed by renewed growth, usually causes a part of the tuber to develop while the remainder continues to harden its skin and mature. The new material is deposited in the tip end, destroying the typical proportions of the variety, or is formed into knobs and prongs that are unsightly. If the season of new growth is prolonged, the old material in the tuber becomes soggy and strong. Some varieties stand drouth much better than others, waiting for the rains, and remaining smooth when new growth is added.

The soil affects quality most materially. Heavy, wet land can not give us a good eating potato. We have in this country some acid soils that are full of vegetable matter, and produce immense crops of potatoes whose skin is exceptionally smooth and clear of disease as a result of the acidity, and yet whose table quality is very poor. For home use and for a discriminating market, a loose, well-drained soil, well-filled with humus for the retention of moisture, will give good quality.

Disposition to Form Setts.—In my own experience a serious fault of many varieties is the habit of too free setting. The grower too frequently is inclined to regard the number of potatoes in a hill rather than the size. The market demands good size, and a rather big percentage of buyers are influenced in their choice by this quality. Only in exceptional cases are the largest tubers the most desirable. They cannot be cooked whole as perfectly as smaller ones, and often they are hollow or hard in the center. The best flavor of a potato is gotten only when it is cooked in its jacket, without a break of the skin, and when so prepared, baked or boiled, the potato of moderate size is most convenient. But the buyer does not recognize these facts, and size is the big consideration in most markets. Size is determined largely by the number of setts, and that is con-

trolled very greatly by the habit of the variety. We exercise some control through the number of eyes left on a seed piece, but even when we cut to a single eye the necessary closeness of the hills may give too many setts, and the small cutting is quite apt to give a vine lacking vitality to bring to full size all the setts it may make. Some varieties are faulty to a marked degree in this respect. Others may set too scantily. But there should be insistance upon the point that we usually have too many tubers in the hill. A little calculation will make this clear. Where we have ten thousand hills in drilled rows on an acre, and have in each hill three tubers averaging two-thirds of a pound each, we have a yield of 333 bushels per acre. In reply, the usual remark of the grower is that many hills will not have any marketable potatoes, and other hills must be large to make the average fair. If this is so ,the fault lies not with the thrifty hills, but with the failures, and it is our business to make ninety-five hills out of every hundred do their full share. I should have liked to say "every hill," but while this is entirely feasible in limited plantings, I do not, in my own experience, find it safe to expect a solid stand of thrifty plants, no matter how much reasonable care is exercised. With some lots of seed, and especially with budded seed, this may be approached so nearly that it is practically perfect, but in the usual field plantings we use some seed pieces that do not grow at all or fail for some reason to make a crop. However, it is only a fair expectation that ninety-five hills out of one hundred will make a fair yield when we use all reasonable precautions as to soil, seed, planting and tillage. With a full stand of plants, the number of setts made by a single vine should be small, and a highly desirable quality in a variety is a disinclination to set as freely as seedsmen give assurance that it will do. A point of superiority in the second-crop seed of the south is its failure to set as abundantly as ripened northern potatoes. It can push to good size all the tubers it forms, if soil and season favor, and the good yields obtained are due to the good size of the tubers rather than to an abnormal number of undersized potatoes.

Resistant Varieties.—In the selection of varieties resistance against effects of drouth, disease and insects, is one of the important considerations. A potato may be prolific and of high quality when the season is entirely favorable, and yet be one of the most worthless of varieties in an unfavorable season. The variation in resistance to drouth and to disease is marked. As soils grow older, drouth affects them more quickly, and as potatoes continue a leading crop of a locality, diseases become established. In selecting a variety for main crop I want to know that it will do relatively well in a bad season. In years of abundance the potato-grower finds prices too low for much profit, and he learns to depend upon other years for

his best income. A good half-crop in a year of general failure means more net income than a full crop when prices are dragging badly. I have grown potatoes that yielded well in a good year but failed miserably in a bad year because the variety could not stand any hot, dry weather, or because it was peculiarly subject to the blight.

We have, to-day, a large number of varieties whose habit of growth is as similar to, and whose characteristics are known to the public as widely in, the Carman potatoes, probably, as in any varieties I might name. This Carman type has a foliage that resists disease well, and the varieties stand drouth better than many others. The branches of the vine are late in making their heaviest growth, and it may be for this reason that early blight does not attack them readily. So far as my observation and experience go, we have nothing better for our hot seasons and drouthy lands than the varieties whose habit of growth cause them to be classed together as a type to which I venture to give the name of Carman because the Carman No. 3 is a well known representative of the class.

Ohio Station Variety Tests.—No other Experiment Station makes as complete variety tests of the potato as does the Ohio Station. The work is in charge of Professor W. J. Green, whose high rank as a horticulturist and whose conservatism and safeness in estimating value are widely known. In Bulletin 133, he publishes some notes on varieties that are descriptive, and will prove most helpful to growers in making selections for trial. His results in bushels per acre are influenced by the soil and climatic conditions of the Station farm, and are not given here, but the characteristics of varieties noted by him will be found fairly correct for most sections of the country. For this reason space is devoted to them, selecting only those varieties that have had a test of three or more years at the Station.

"Notes on Varieties, Bulletin 133, Ohio Station.—The following notes on varieties are rather more descriptive than usual, for the reason that such descriptions will tend to help those who are about to make selections for special purposes:

In selecting a variety, one must first fix in mind an ideal of that which is needed for his particular purpose, whether for the table or for market, and often for a special market, which may require a potato of a particular shape or color. With this ideal in mind he can be much more definite in his search for the desired variety.

In these descriptions, particular characteristics are given as far as we have been able to give them, and attention is called in many cases to resemblance to other varieties. So far as adaptability of varieties to certain soils is concerned, not much help can be given, any further than to state that the soil on the Station farm is made up of considerable quantities of silt, mixed with clay, and is usually described as a clay loam. It is moderately fertile and has not been

highly enriched. It is better adapted to wheat and potatoes than to corn. The potato crop seldom fails on this soil, but large yields are not often secured.

The depth at which potatoes grow is influenced largely by the method of cultivation; thus the notes on this point would not hold true under a method differing materially from that used at the Station, which is practically level culture.

The notes given on tendency to sprout and keeping qualities of the various varieties have been made from rather limited observation, and some of them may have to be modified after further experience:

Acme.—Plants medium size, sixteen to twenty inches tall; somewhat spreading, more so than Early Ohio or Early Trumbull; medium to large leaflets, healthy; blights but little.

Tubers medium size; resembling Early Ohio in form and color, although not a uniform. The most noticeable difference in appearance between the Acme and Early Ohio is in the eyes, the eyes of the Acme being more deeply set than those of the Early Ohio; skin quite smooth; tubers grow medium depth and close together; yields about the same as the Early Ohio and ripens at about the same time. Does not sprout easily and is a good keeper.

Banner.—Plants twenty to twenty-five inches tall; slender stems, purple at base, thin foliage, dark color.

Tubers resemble Carman No. 3; potatoes grow medium in depth and quite close together. In 1899 yielded very heavily, in 1900 yielded well, in 1901, was not grown at the Station.

Bovee.—Plants twenty to twenty-four inches tall; a strong grower; large stalks, three to five in number; somewhat spreading; leaflets large, thick foliage; not much inclined to blight.

Tubers medium size; medium length; cylindrical; color white with pink markings; eyes medium size and depth. Not quite as early as Early Trumbull, Acme or Early Ohio. A prolific and profitable variety. Does not sprout badly and is a good keeper.

Carman No. 3.—Plants twenty-two to twenty-three inches tall; upright; branches grow upright and slender; foliage medium dark color; vigorous.

Tubers medium to large; short; slightly flattened; often tapering toward stem end; color white, not quite as clear as Rural New Yorker No. 2; skin smooth; eyes few and shallow; tubers grow medium in depth and close together. A good market variety, but not of the best quality. Small and unmarketable tubers very few. Some varieties give a greater total yield per acre, but few excel it in marketable product. A medium late potato. Sprouts quite easily; is a fairly good keeper, but not as good as some varieties.

Commercial.—Plants twenty-two to twenty-six inches tall; a

strong grower of upright tendency; thick heavy stems; very thrifty appearance; peculiar growth, branching out like a tree.

Tubers medium to large, very few, too small for market; form somewhat irregular; medium length; tapering toward stem end; flattened; color, light pink, nearly white; surface irregular; deeply indented at places, usually at eyes; would waste considerably in paring; skin somewhat rough; eyes small and medium to shallow, except where indented. Potatoes grow scattering in hill and medium depth. Quite prolific, but too large a per cent. off shape. Does not sprout easily. A good keeper.

Dewey.—Plants twenty to twenty-five inches tall; upright, tall slender stems, purple at base; foliage resembles Carman No. 3 in manner of growth but is a shade lighter in color. Not very much inclined to blight.

Tubers medium to large; form quite regular; short; somewhat flattened; usually tapering toward stem end; resembles Carman No. 3 in form, a little more regular perhaps; color clear white, about the same as Rural New Yorker No. 2; skin very smooth and clean; eyes few; rather large, shallow. Potatoes grow close together and medium in depth. Does not sprout quite as easily and seems to be a little better keeper than Carman No. 3. Ripens with Carman No. 3.

Early Dawn.—Plants sixteen to twenty inches tall; slender stems; large leaflets; foliage medium; dark color.

Tubers medium size; medium length; cylindrical; resembling Early Rose somewhat in form; color pink, about the same as Early Ohio; skin smooth; eyes quite large, medium depth. Potatoes grow medium in depth and close together. Does not yield as well as most early varieties. Does not sprout quickly and seems to be one of the best keepers of the early varieties.

Early Harvest.—Plants eighteen to twenty-two inches tall; upright, spreading; a strong grower; medium sized stems; medium dark color. Not very subject to blight.

Tubers medium size; 12 per cent. too small for market in crop of 1901; medium to long, slightly flattened; color white; skin smooth; eyes quite large, medium depth. A clean looking potato. One of the best early white sorts that has been given a long trial at the Station. Sprouts quite quickly but remains firm even after having sprouted somewhat.

Early Michigan.—Plants eighteen to twenty-two inches tall; spreading; large leaflets; dark colored foliage; stems medium size.

Tubers medium to large; medium length; flattened; oval; color white; skin quite smooth; russeted somewhat, giving a brownish appearance; eyes small, shallow; a good many small potatoes in 1901; 15 per cent. unmarketable. Does not run as large nor as even

as some; quality good. Total yield about the same as Early Harvest. Sprouts quite quickly but keeps fairly well.

Early Ohio.—Plants twenty to twenty-four inches tall; an upright, spreading grower; large stems, medium sized leaflets.

Tubers medium size; medium, rather short, cylindrical, run quite even; color pink; skin quite smooth but not as smooth as Early Fortune or Early Norwood; eyes medium size, quite shallow, rather conspicuous. Potatoes grow quite close together and medium in depth. This is still the standard early variety. Does not sprout quickly and keeps as well as any early variety.

Early Thoroughbred.—Plants twenty-two to twenty-six inches tall; spreading, covering a good deal of ground; medium sized leaflets, dark color; not much inclined to blight.

Tubers medium size; form variable, quite long, some taper toward one end and some toward the other and some toward both ends, flattened; color dark pink, much like Early Norwood; skin inclined to be rough over a part of the surface; eyes medium size, shallow. A good early variety. Possibly an improvement upon Early Rose. Sprouts quite quickly. A fairly good keeper.

Early Trumbull.—Plants eighteen to twenty-two inches tall; quite spreading vines, thrifty; foliage thick, medium dark color.

Tubers medium to large; form variable, some medium length, some quite short; slightly flattened, a little irregular; color white; skin usually smooth, sometimes roughened; eyes small, shallow, inconspicuous. Has proven to be one of the best early sorts tested here, yielding ahead of most early varieties. Sprouts quite quickly. Keeps about the same as Early Thoroughbred.

Early White Ohio.—Plants sixteen to twenty-two inches tall; a medium sized grower, with upright tendency; does not spread much; slender stem; medium to large leaflets; foliage medium density; light color.

Tubers medium to large; medium length; some quite short, slightly flattened; a little irregular; color white; skin inclined to be rough over about half of the surface; eyes medium size, shallow. Appears not to be very prolific. Sprouts quite quickly. Keeps fairly well but not as well as most other Ohio sorts.

Enormous.—Plants twenty to twenty-two inches tall; rather tall, spreading variety; large stems; large leaflets; foliage medium in density; light in color.

Tubers large to very large; rather long; slightly flattened; often irregular; color white; skin inclined to be rough on many specimens; eyes variable in depth, but mostly shallow and inconspicuous. A heavy yielder and a good market variety but of rather poor quality. This variety has not given satisfactory yields generally, but has near-

ly always done well at the Station. A medium late variety. Sprouts quite quickly but not very badly. A good keeper.

Extra Early Pioneer.—Plants sixteen to twenty-two inches tall; a strong growing, rather large plant; medium sized stems and leaflets; very little tendency to blight.

Tubers medium to large, few too small for market; mostly long, slightly flattened, some oval, tapering toward stem end; color pink, lighter than Early Ohio, about the same as Baker's Extra Early; skin inclined to be rough on some, usually smooth; eyes medium to large, shallow. Gives about an average yield for an early sort. Sprouts quickly.

Gem of Aroostook.—Plants twenty to twenty-four inches tall; thick stems, upright, somewhat spreading; medium dark colored, thick foliage; blights some but not badly.

Tubers medium to large; medium length; flattened; color white; skin very smooth; eyes numerous, medium size, shallow. Appears to be promising as a midseason variety. Does not sprout very badly. Apparently a good keeper.

Green Bay Triumph.—Plants twenty to twenty-four inches tall; a medium tall, spreading grower, with large stalks and leaflets; foliage light color; quite inclined to blight.

Tubers small to medium; very short, length often less than diameter; roundish, usually slightly flattened; color yellowish white with pink tint to eyes; skin fairly smooth; eyes medium size, shallow. Yields about the same as Early Ohio. Does not sprout badly. A good keeper.

Irish Queen.—Plants eighteen to twenty-two inches tall; a strong, compact grower, not very spreading, upright, large leaflets, thrifty.

Tubers medium size, short, a little irregular, some oval, some rounded, mostly flattened; color white, about the same as Rural New Yorker No. 2, except a slight pink tint about the eyes; skin quite smooth; eyes small, shallow, inconspicuous. Potatoes grow shallow and close together. Not a heavy yielder. Sprouts quickly, and is inclined to shrivel; not a very good keeper.

Joseph.—Plants twenty to twenty-four inches tall; spreading; stems thick; dense foliage; very little tendency to blight.

Tubers medium size; 20 per cent. too small for market in crop of 1901; medium to long, flattened, oval; color light pink, about the same as Extra Early Pioneer; skin quite smooth; eyes small, mostly shallow, some medium depth. Potatoes grow medium depth and close. A fairly good but not heavy yielder. Sprouts quickly and is not an extra good keeper.

Lakeside Champion.—Plants twenty to twenty-four inches tall; an upright spreading grower, medium sized stems, slightly irregular in row; somewhat inclined to blight.

Tubers medium size; medium to long, considerably flattened, tapering toward one end or the other; color white; skin a little rough; eyes medium size, shallow; too irregular for best appearance. Sprouts quite quickly. Not a very good keeper.

Livingston.—Plants eighteen to twenty-four inches tall; a tall, upright, spreading grower, very vigorous, thick stems; not inclined to blight.

Tubers medium to large; medium to long, uniform size nearly entire length, sometimes tapering; slightly flattened; color white, pink eyes, discolors quickly and badly on short exposure to light; skin sometimes slightly russeted; eyes small and shallow. A good yielder and cooker. Does not sprout quickly. Is very firm and a good keeper.

Pat's Choice.—Plants twenty to twenty-four inches tall; upright, spreading, very even in row; slender stems, medium thick foliage, thrifty; not inclined to blight.

Tubers medium to large; medium to long, slightly flattened, some taper toward stem end; color pink, eyes decidedly pink; skin usually smooth, some specimens quite rough; eyes few, small, shallow. A good potato, shapely, fine appearance, and of good quality. Yields about the same as Sir Walter Raleigh. Does not sprout quickly and is a good keeper.

Pingree.—Plants eighteen to twenty-two inches tall; upright, somewhat spreading, very even in row, thrifty, thick stems; not very susceptible to blight.

Tubers medium to large; medium to long, slightly flattened, of uniform diameter nearly the entire length; color white, about the same as Rural New Yorker No. 2; skin smooth; eyes medium size and medium depth. Potatoes grow shallow and quite close together. Yields about the same as Pat's Choice. Sprouts quickly but remains quite firm and is a fairly good keeper.

Sir Walter Raleigh.—Plants twenty-two to twenty-six inches tall; a tall, upright, spreading vine; large stalks, slender upright branches, resembling Carman No. 3 in manner of growth. Not much inclined to blight.

Tubers medium to large; short, thick, slightly flattened, tendency to oval, resembling Carman No. 3 very much in form; color white, but not as clear as Rural New Yorker No. 2; skin smooth, clean; eyes few, small; usually very shallow and inconspicuous. A good market sort. Sprouts quite quickly; keeps about the same as Carman No. 3.

State of Wisconsin.—Plants twenty to twenty-six inches tall; upright, dark colored leaflets, several small hills; but inclined to blight much.

Tubers medium to large; very short, some somewhat flattened.

mostly not flattened, some quite oval; color clear white, same as Rural New Yorker No. 2; skin very smooth and clean; eyes few, small, shallow, inconspicuous. A very clean looking potato. Not a very good yielder. Does not sprout badly. Has fairly good keeping qualities.

Suffolk Beauty.—Plants twenty to twenty-four inches tall; a rather tall, upright, spreading grower; large stalks and branches; very little tendency to blight.

Tubers medium to large; short to medium, thick, somewhat flattened, some quite oval; color white, although not very clearly so, seems to have a pinkish tint; skin quite smooth; eyes large, shallow to medium depth. Resembles Quick Crop somewhat. Has yielded about the same as Carman No. 3 at the Station. Sprouts very little. A good keeper.

Triumph.—Plants eighteen to twenty-four inches tall; a rank grower, spreading, large heavy stalks; very much inclined to blight.

Tubers medium size; short, rounded, quite regular; color deep pink; reddish; skin quite smooth; eyes rather deep; grows scattering and shallow. Not a good color. Very early but of poor quality.

Uncle Sam.—Plants twenty to twenty-four inches tall; upright, somewhat spreading grower; large stalks, stands up well; not much inclined to blight.

Tubers medium to large; medium to long, slightly flattened, some oval, some taper toward one end or the other; color white; skin smooth; eyes small to medium size, shallow. A fine looking potato. Quality, fair; a good yielder, and a good keeper.

Vigorosa.—Plants twenty to twenty-five inches tall; upright, spreading, large stalks, even in row, heavy foliage; very little tendency to blight.

Tubers medium to large; medium to long, mostly considerably flattened, oval, quite uniform; color white; skin quite smooth, with slight tendency to roughness on seed end. Tubers of good size, shape and appearance. Yielded as well or a little better than Sir Walter Raleigh the past three seasons at the Station. Sprouts quite quickly, a little inclined to shrivel, but a fairly good keeper.

White Beauty.—Plants twenty to twenty-eight inches tall; upright, spreading, slender stems, irregular in row; somewhat inclined to blight.

Tubers medium to large; long, nearly cylindrical, slightly flattened, mostly of uniform diameter nearly entire length, some taper slightly; color white; skin a little rough, russeted over entire surface; eyes very small, very shallow, inconspicuous. Has yielded about the same as Joseph the past three seasons. Does not sprout very quickly, and remains very firm, apparently one of the best keepers.

White Bliss Triumph.—Plants eighteen to twenty-four inches tall; upright, not very spreading, heavy stems, not much branches, large leaflets, foliage thin; not much incline to blight.

Tubers medium to large; very short and thick, diameter usually greater than length, very slight tendency to flatten; color white, very slight pink tint to eyes; eyes few, quite large, shallow; skin fairly smooth. Resembles Junior Pride of the south very closely. A fair but not heavy yielder. Does not sprout quickly. A good keeper.

White Mountain.—Plants twenty-four to thirty inches tall; upright, large stalks with long slender branches, regular in row, heavy foliage; very little tendency to blight.

Tubers medium to large; short to medium, quite thick, some slightly flattened, others not at all, some oval, some cylindrical; color white; skin has a tendency to roughness around seed end; eyes medium size, shallow to medium depth. A standard potato in some sections of the country. Has given as good or better yields than Carmen No. 3, at the Station. Does not sprout quickly. Is firm and a good keeper.

Whiton's White Mammoth.—Plants twenty-two to thirty inches tall; upright, spreading, stalks thick, foliage thick, long slender leaflets, regular in row; not much inclined to blight.

Tubers medium to large; short to medium, rather thick, not very uniform, some taper quite decidedly, flattened; color white; skin quite smooth; eyes small, medium depth. A good yielder and a reliable market sort. Sprouts quite quickly, but seems to be a good keeper."

To this list of varieties that have been given a three years' test at the Station, I desire to add one that has received a single year's test —the Early Fortune. This variety is showing value in sections devoted to the growing of early potatoes and is one of the best of which I have knowledge. Professor Green's estimate from a single year's test is as follows:

"Early Fortune.—Plants twenty to twenty-five inches tall; upright, broad spreading; a strong grower. Has very little tendency to blight.

"Tubers medium to large; medium length; slightly flattened, tapering toward stem end; color pink; a trifle lighter than Early Ohio; skin smooth; eyes medium size and depth. A clean looking potato; has a smoother, neater appearance than Early Ohio. One year's trial indicates prolificacy. Sprouts quite quickly but keeps well."

In these notes of Prof. Green, the "blight" referred to by him is not the "late" blight, as I understand it, but the "early" blight which causes premature death of vines, not attended by rot.

PLANTING POTATOES.

No arbitrary rules can be laid down safely for our government in the growing of any crop. Soil and climate are varying factors to be considered. But we can know the nature of the plant we would grow, and learn what conditions favor it, and then use those methods which, in our particular instance, will most nearly secure those conditions. We have learned that the potato likes a cool, moist soil, and we know that extreme heat is harmful. A corn plant likes heat. We learn to guage roughly the yield of corn in the United States by watching the range of the thermometer. There must be moisture for corn—moisture is the first essential in all plant growth—but moisture with absence of normal heat will not give us a good crop of corn. Great heat with normal moisture will give us a very big yield. Heat fills the cribs rapidly. This cereal being a heat-loving plant, we wait until the ground is warm before planting; we do not plant deeply but let the first roots feed at the surface, and we try to utilize the mid-summer heat for forming the ear.

But the potato, as we have seen, does not want so great a degree of heat. It thrives best in the most northern States, or on mountain ranges having the climatic conditions of more northern regions. It wants the cold that corn dislikes. In the center of the corn belt we plant that grain after the soil warms up, and yet early enough to bring the earing stage in mid-summer when there is abundance of heat. In the latitude of best corn production we have too much mid-summer heat for the potato, and we learn to do one of two things: To plant very early and get all growth possible before August, or to delay planting so late that the vines will be making their best development of tubers in September when the nights are cool. Where the planting is very early, even in case of medium varieties, a fair yield may be gotten by the first of August. If that month should be unusually cool, a maximum crop is gotten, but we count upon the time prior to that date. When the planting is late, we do not want any approach to maturity of vines until the fall brings cool weather favoring growth of tubers. For this belt nothing can be said in favor of planting at a time half-way between early and late. The vines reach a stage of growth that makes them subject to the diseases that develop in great heat, and yet have not had time for making a crop. Farther north these conditions do not prevail; the summers are cooler, and planting in May is as safe as earlier or later.

Early or Late Planting.—No one can decide whether early planting or late planting will give the best results until each is given a faithful trial. It is a matter of soil, climate and market conditions. Some localities succeed admirably with June-planted crops while other localities of the same latitude fail utterly. It is largely a ques-

tion of moisture. If land have plenty of humus, or if it be so located that autumn rains may be counted upon with some certainty, there is much in favor of growing the crop in the cool days of fall. The season of cultivation is shorter, there is better control of weeds, early blight is less to be feared, and there are fewer insect enemies. As a rule, moreover, when June-planting does succeed, the yields of these late-planted fields exceed the yields from early planting, so that decreased expense in growing is attended by increased yields.

One serious objection to late potatoes is interference with a crop rotation that is desirable in the belt of which I write. For thirty years in my own experience have I noted the advantages of a three-years' rotation of potatoes, wheat and medium red clover. Potatoes pave the way for wheat, giving a nearly perfect seed-bed, but this is possible only with the early-planted crop. I do not mean early varieties, necessarily, but medium varieties, like the Carman, planted very early, which make their crop before fall, and can be harvested before time for firming the seed-bed for fall grain. A late crop of potatoes does not get out of the way for fall seeding, and disrupts one of the best crop rotations known.

There is the additional objection, and a most serious one for the belt of which the fortieth parallel of latitude is a central line, that the crop comes into the most direct competition with the northern potatoes that are grown under the most favorable climatic conditions and can be placed upon the market more cheaply than our more southern crops. I incline to think that the best money has been made in late years by those growers who had a ripened crop ready for market before frost. The autumn frosts stop the growth in the northern fields, and there is a rush of their product upon the market that nearly invariably causes a decline in price.

The disadvantages of early planting may be great. Heavy spring rains are not infrequent, and cause some rotting of seed. They pack the soil seriously, undoing much of the work of preparing it for planting. Late frosts may cut the tops, and such damage cannot be fully repaired by the plant. The stem underground may not rot, but it sends out too many branches to take the place of the old top, and the yield is rarely, if ever, satisfactory. The potato beetles and the flea beetles time their arrivals to catch the early-planted fields at a tender stage. But in very much of the belt of country mentioned there are advantages that counterbalance all disadvantages. A chief one is the probability of a better supply of moisture in the first half of the year than in the latter half. There may be no more rainfall, but evaporation is less rapid. Indeed in this belt the area devoted to a late-planted crop is far smaller than that given to early planting, experience having demonstrated the danger of drouth in September. The time of planting is a matter to be de-

cided by the grower for his own soil and market—either quite early or quite late. He may do best to get his chief growth before August; he may do best to hold the crop back for the cool season after August. A compromise between these dates is not satisfactory in the ordinary season, for the reasons stated.

Depth of Planting.—Just as our knowledge of the nature of the potato guides us in determining the time of planting, and the correctness of our knowledge is attested by our experience, so are we guided in respect to the method. Much failure in the potato crop is due to shallow planting. It is all right to plant corn shallow—it wants the heat, and should root in the surface soil; but the seed potato should be down where the soil is cool and moist. The depth depends upon the soil. If it be loose and well-drained, a depth of four or five inches under the level of the surface when firmed with the hand is not too much. If the ground is heavy and not well drained, a less depth is better. Experience was required to convince me that I was not planting three inches deep when dropping by hand in furrows apparently five inches deep. The sides of the furrows, the pieces of turf that held the seed up from the furrow bottom, the ridge thrown over the seed—all help to deceive one concerning depth. After the planting, when the soil had been made level with the plank drag, the seed would be found not two inches below the firmed surface. This is a common mistake, and a serious one. It is true that a soil may be so heavy in texture and so wet that it is wholly unfit for the crop, and if it is planted the seed should be left very near the surface so that the plant roots may have air, and that the tubers may grow in loose soil thrown up into a ridge late in the season; but planting in such ground is too hazardous for the man who has a living to make in this world. It is better to underdrain, and thus to lower the level of soil water, and to make the soil loose by the addition of organic material; then potatoes can be planted at a good depth with chance of a fair crop almost in any season. For heavy soils, no matter how well drained, three inches of depth below the leveled and firmed surface may be sufficient; for looser soils the depth should be greater. I do not mean that the covering should be a certain depth, but that the potato should be placed at the depth mentioned below the level of the surface of the land.

The Covering.—When planting in soils at all heavy, and especially if the planting be early so that heavy rains are probable, I esteem the manner of covering the seed one of the most important points to be observed. My conviction in this matter rests first upon the improved yields secured in my fields during the five years that I have been covering the seed very shallow. A few years previous to the adoption of the present method it was realized that the potato seed should be planted at a good depth, where there was moisture and a

degree of coolness not found at the surface. Accordingly the planter was set to run to a depth of four inches, or thereabout, and the disks threw up a ridge that gave added depth for the time. This ridging of the soil over the row was an old-time practice of the community to secure control of weed growth. The ridges were left about two weeks, and then the ground was floated level, giving fresh, clean soil in rows for the potatoes that would soon appear above ground. This method of covering has much to commend it for all loose soils, and probably no better one can be devised. But I found finally that it was all wrong for a heavy soil. Rains would follow our early planting, settling the soil closely about the seed pieces, excluding all air and light. Digging down to see what stand of plants was promised, I found in every wet season that the sprouts, as they left the eyes, were too small and weak. They would increase in size as they approached the surface that had been made loose with harrow or weeder, but no plant of that sort ever makes a full yield. It was seen that good depth was needed in planting, and yet the results were not encouraging whenever heavy rains came soon afterward. If the soil had been of loose texture the results would not have been grave, but most good potato soils are inclined to heaviness, as only these can withstand drouth with much success.

The Cornell Station has done invaluable work for growers through the experiments conducted by Professor Roberts and Mr. L. A. Clinton. It has called wide attention to the value of tillage and of humus in the soil. This Station has practiced deep covering of the seed, throwing the ridge over the row and dragging it down before the plants were up to the level of the ground. Vigor of the plants caused the good results of the Cornell Station to puzzle me greatly until I visited the Station and examined the soil. It is a loose soil, two-fifths being rotting gravel, and the heavy covering given to seed would not pack. In the case of such soils there can be no particular objection to deep covering. The air is not excluded and strong sprouts can be secured. But the method is not advisable for any other than porous soils.

Securing Good Buds.—Under the head of "Budding" reference was made to a modification of the original method that was feasible for the extensive planter. The plan of covering the seed deeply was as wrong in theory as it proved to be in practice. The bud on the seed piece was far from light and air when rains had sealed up the ridge of soil thrown over it by the disks of the planter. The result was that the young sprout did exactly what it does when starting in a dark corner of a cellar, or in the center of a pile—it stretched out for the light, making a spindling growth. Seed exposed to the light starts strong buds—there is no stretching toward the light because they are in it. The farmer who plants early and extensively usually

does not have time or place for exposure of seed to sunlight to get strong buds, and yet in a soil that is not very open he does wrong to place a heavy covering over it that will become close when rain saturates it.

The natural thing to do is to plant without any delay when the ground permits, to put the seed into furrows sufficiently deep to permit deep rooting, and to cover so slightly that there is a degree of exposure to the light and air. This is easily done with a planter, and less satisfactorily so by hand. I have learned that when the soil has been prepared for the seed, there is no need of any opening shovel on the planter, the shoe doing perfect work. Neither is there need of any covering disks. When the soil is fine, loose and properly dry for work, it falls back into the furrow made by the shoe after the seed piece has dropped into place. Not much falls back, but not much is wanted. At the usual depth to which the shoe should go, there is loose, moist soil to surround the seed, and such a covering is far better than the small, dry clods that form at the surface in the sunshine and are dumped upon the seed by covering disks. After five years experience in field practice I can say safely that the method works most perfectly when the soil has been properly fitted, and the outcome is an even stand of strong plants because the eyes start under so slight a covering that they may be said to be budded in the light.

It is best to attach a small section of a log to the rear of the planter by a wire, making the log drag along in the furrow over the potatoes to perfect the covering. Some seed pieces may have been left uncovered, and some have more soil fallen in upon them than is wanted, and this log—four feet long and eight inches in diameter—evens it somewhat. When the planting is finished, the field is in furrows apparently ready for hand-planting, and the seed is under the bottom of these furrows just deep enough to be covered from sight.

It may be thought that seed in this position would be unusually subject to injury by heavy rains or by drouth, but experience shows that it is otherwise. If a soil becomes saturated, the excess of moisture in the row will be held about the seed pieces for a longer time when a ridge of soil has been piled into the furrow than when it is open so that the air can dry it out. A mass of saturated soil over the potato will do more harm than an open furrow because the water will remain in it longer. I have observed closely in respect to this, and apprehend no more damage from excessive rainfall on potatoes covered very shallow in deep furrows than on potatoes planted in the common way, but rather less damage.

In drouth, this method gives good plants. A fresh-cut seed piece

should not be placed in contact with very dry soil. There are repeated instances of failure when such fresh-cut seed has been dropped by hand in old furrows whose surface was very dry. The soil becomes a sponge that absorbs the moisture from the potato. But when the shoe of the planter is run deep, as in this method of planting, the potato is slipped into the moist soil, and the covering is from the sides of the furrow made by the shoe. It is fine soil, not hardened into minute clods by exposure to the air on the surface, and unlike the covering gathered by the disks in our rather clayey fields when the planter runs less deep and all the covering is given by the disks that gather up the surface soil. The fine and moist soil about the seed piece does not dry out readily because it is below the moisture level in the middles between the rows. If the potato seed were not cut, there would be no need of any moisture. The potato would start its buds just as readily in the absence of moisture as is done when seed is budded on the barn floor. After good sprouts have been started, and roots are put forth at the base of the sprouts, moisture is needed. In my own experience there has been one year when, on account of poor physical condition of the soil, I feared that the seed was too dry after the buds had started, and having secured the strong sprouts desired, the furrows were filled at once. But the method of planting that is recommended here for rather heavy soils can be accepted as safe in any sort of a season, and especially beneficial in a wet one that would close up a heavy covering of soil and thus exclude light and air from the seed at a time when it most needs it, viz., when it is putting forth its buds.

Time of Cutting Seed.—In extensive planting the cutting of seed several days ahead of the planting cannot be advised, though some successful growers practice it. The serious objection is the danger of injury in case planting is delayed by the weather. Cut seed will heat if put in considerable bulk, and when not in bulk it is liable to dry out too much. By the use of potato boxes it may be kept in fair condition for a considerable period of time. The pieces should be dusted with plaster and the boxes should be tiered so that they can be covered with canvas to prevent the air from entering freely. In hot, windy weather a few hours exposure of cut seed spread on a floor will dry it unduly. The advantages of cutting seed considerably ahead of planting are the saving of time when the ground is ready for field work, and the decreased liability to rot in the ground if a rain should follow the planting closely.

But there always is danger of a protracted wet spell during the planting, and the risk of losing the seed, or of having it damaged, when cut and unplanted, is so great that most extensive growers are agreed upon the plan of cutting the seed as wanted by the planter. A seed piece heals no more nicely anywhere than in fresh soil. The

one danger is that of rain before there is time for healing. In my own experience this is a thing to be feared. When a shower falls upon seed planted within two or three hours, the chances are that the fresh-cut surface of the seed pieces will not heal nicely, but will begin to slough in spots, and while there may not be missing hills, the plants are not as vigorous as those from undamaged seed. Seed cut and healed ahead of planting time can withstand the water. But everything considered, as a matter of fact in experience, it seems wisest not to cut more seed ahead of the planter than can be used before bad weather interrupts the work.

In Dry Furrows.—A number of instances of a poor stand of plants are directly traceable to exposure of fresh cut seed in dry furrows for a short period before covering. When the sun is very hot and the furrow is dry, a piece of cut seed should not lie uncovered. In the old way of hand-dropping and covering with a plow I have left a strip of land uncovered during the noon hour when the furrows were dry and the sun was very hot, and have had a poor stand of plants on that strip, while the remainder of the field, with similar soil and seed, had good plants. Whole potatoes would have been uninjured, but the cut pieces were badly damaged.

Potato Planters.—In the case of cereals, the automatic planter does good work because the seed varies little in size and is not injured by handling. The work of automatic potato-planters is less perfect for obvious reasons. The seed pieces are uneven in size, tender and more inclined to feed irregularly. Much has been done to obviate the difficulties, but I incline to think that we ask too much of the planter. So far, at least, no machine has been devised that will make no misses when all the work is left to it, and it is profitable to depend in part upon human labor. A machine can be so constructed that it will place the great majority of the pieces where they should be, but if five per cent. of the hills are missed in planting, the loss will be considerable. The missing hills on an acre of ten thousand hills would be five hundred, and if a hill represent only one pound of potatoes, the total decrease in yield due to faulty machine work would be over eight bushels. Ten per cent. is not an unusual rate of missing among the automatic planters on the market.

It is better to make a planter that will do all that reasonably may be expected of it, and have provision for aid from an extra man or boy carried on the planter. In this way it is possible to have the work done without any misses at all, except where the seed piece is thrown in the furrow by the motion of the planter.

A planter does better work in some ways than can be secured from hand-planting. The seed is brought into a straighter line, and there is greater evenness in depth. Straight rows, or rows in which the plants do not stand zig-zag, can be cultivated more perfectly than

others. When seed is dropped into the ordinary furrow, the pieces often fall to one side or to the other of the center, and are held up by little clods or other soil that has fallen back from the sides. I should prefer to pay one dollar an acre for use of a planter rather than to have the work done by hand free of charge. But the planter must be a good one that does not miss hills in its work.

The man who plants five acres of potatoes a year should have the use of a planter. Ownership of such implements is desirable because then there need be no delay when the work should be done, though the hiring of implements may be entirely feasible in many instances. But in all this there is no desire to discourage the man who wants to plant only two or three acres a year and can not hire potato machinery. He is not greatly handicapped in his competition with larger growers. His small acreage can be given plenty of care, and can be made to yield nearly as much net profit per acre as that gotten in large fields by use of special machinery. The furrows opened to receive the seed should have a chain dragged through them to push small clods or loose soil to either side, straightening the line in which the pieces fall. The covering should be moist soil if the seed is fresh cut. The seed should be cut with such care that all bad pieces are discarded. In these ways the prospect for a crop may be made even better on a small plat than that of a large field where there is constant temptation to rush the work at the expense of future results.

There is an old custom of putting two seed pieces into each hill. It has its advantage in case of the use of untrustworthy potatoes for planting, as there is the chance that if one piece does not send up a good plant, the other piece, cut probably from another tuber, may give a good plant, and the hill is not a total failure. But when care is taken to have good seed, nothing is gained by cutting fine and using two pieces in a hill, while there is loss from unnecessary exposure of cut surface to the soil, be it wet or dry. When a lot of seed is good enough to be used, there is loss and no gain from such fine cutting that two seed pieces are required in a hill.

Distance Between Hills.—The width between rows is governed by the habit of growth of the variety. The rows should be sufficiently close to secure thorough shading of the surface when the vines have reached full growth. The shading prevents evaporation of soil moisture and helps to protect the stems from the burning rays of the sun. Thirty-six inches between rows give sufficient space for any variety, and for early varieties I prefer not more than thirty-two inches. In the drilled row the distance between hills is governed by the amount of seed used in the hill and by the variety planted. Assuming that the seed piece is a fair-sized block of potato containing two strong eyes, eighteen inches give good space for rank-growing varieties. Land may be so foul or heavy that checking is best, but in

case of ordinary soils, properly handled, drilling is to be preferred. Good tillage at the right time gives control of weeds, and the better distribution of the plants gotten by drilling favors the yield of crop.

Applying Fertilizers.—Theoretically all fertilizers should be distributed throughout the soil. The plant roots go everywhere, and the feeders are formed chiefly near the tips of the roots. When available fertility is supplied close to the base of the stalk and there only, the plant roots do not spread as rapidly throughout their whole feeding ground as they should. In a loose soil that demands no deep tillage after the potato plants are up, the fertilizer should be broadcasted and worked into the ground before planting, or else applied with a fertilizer drill. But experience with rather heavy potato soils leads one to practice some row fertilization. The tillage must be deep later in the season than is favorable to wide root growth, and there should be a full supply of plant food in the row. In such cases it may be a good plan to use the fertilizer drill as a harrow in preparing the seed bed, applying one-half of the fertilizer. The other half may be applied in the row when planting, or later if the deep furrow with light covering be used. In the case of early potatoes it is often advisable to put all the fertilizer in the row. Planters have fertilizer attachments. When the planting is done by hand, and the fertilizer is put into the furrow before the seed is dropped, it is a good plan to go over the ground with a two-horse wheel cultivator and mix the fertilizer in the furrow. With one narrow shovel on each side of the cultivator, two rows may be prepared at a time. It will be found that a trace chain, fastened to each shovel and let drag behind in the furrow, will push little clods aside and assist greatly in securing an even depth for seed and straight rows. The seed can be dropped by hand in such furrows in lines nearly as straight as those made by a planter.

But when the deep furrow with light covering is used, the fertilizer for the row may be effectively applied after the planting, and my individual preference is for this way. The potato needs no fertilizer for two weeks, or even longer, in the cold spring, because the sprout is fed by the seed piece. If there be nitrate of soda or other soluble carrier of costly nitrogen in the fertilizer, rains waste it. The available phosphoric acid, in my opinion, is most effective when first applied to the soil. There is no better time to apply such fertilizers in the row than when the sprouts are ready to come through the little soil that covers the seed pieces. It falls where some of the roots will form, and is ready to push growth. It is practicable to apply with a grain drill having a fertilizer attachment, spreading the horses with long neck-yoke and double-tree so that they have two rows between them. All holes in feed-box may be closed except the ones over the two rows. The drill should have extra large capacity, as is now provided for distribution of ground lime, and then the fer-

tilizer can be fed out in the desired quantity. All the hoes should be let down so that the ground may be cultivated, though only two or four are distributing fertilizer. On account of the deep furrows, the hoes do not disturb the setts, and the cultivation partially fills the furrows, killing weeds and adding needed covering to the potatoes.

But the grower of a few acres only may prefer to distribute the fertilizer by hand in the furrows, and the best work is done in this way. When it has been so scattered, a weeder or harrow should be used to make a partial filling of the furrows. In a few days the plants again appear, and another cultivation will complete the filling, giving clean, fresh soil in the row. Where the soil is loose, the weeder does this work well; in stiffer soils the harrow or spring-tooth wheel cultivator is more satisfactory.

In defence of the practice of applying commercial fertilizers in the row, it is a pleasure to be able to quote so good an authority as Professor E. B. Voorhees. In his book on "Fertilizers," page 217, he says: "In reference to the method of application, while very good results are secured from the application of fertilizers directly in the row, this is to some extent influenced by the character of the soil. Where the soil is somewhat heavy and the circulation of water is not perfectly free, it is less desirable than where the soils are open and porous and free circulation is not impeded; though where the amounts supplied are considerable, it is recommended that at least one-half of the fertilizer should be applied broadcast and worked into the soil, and the remainder placed in the row at the time of planting. Naturally, when the soils are poor, a concentration of the constituents is more desirable than when the surrounding soil possesses reasonably abundant supplies of available food."

CULTIVATION.

One object of cultivation is to kill weeds. In potato-growing it is essential that the ground be kept clean by destroying the weeds before they make much root. With the old method of planting shallow and ridging the covering, we got clean soil by dragging the ridge down immediately before the plants reached the surface. It was a good way of starting the potatoes ahead of the weeds. But we get the same results from leaving a furrow open over the plants and filling in as the plants grow. When they are above the level of the surface, the furrows have been filled with loose soil, and all weeds have been destroyed. It is always possible that rains may interfere with the work, and some weeds may be among the potato stalks in the unfilled furrows, but it is safe to use a wheel-cultivator, throwing plenty of soil against each side of the plants, and if some ridging is

done to secure complete burying of all weeds, the ground can be leveled with the weeder without injury to the potato tops.

Until the plants are a few inches high, cultivations with weeder or slant-tooth harrow should be given whenever weed seeds are sprouting or a crust is forming.

One Deep Working.—We now come to a cultivation of a kind that seems severe to the plants, and yet in all soils except the loosest it is essential to maximum crops. The potato makes its crop down in the soil. The physical condition of the land at time the crop is produced is more important to it than it can be to corn. The latter plant makes its crop in the air, and has all the room it wants; the potato must displace soil to get room for its tubers. A naturally loose soil will remain in good physical condition throughout the season, but such soils are rarely retentive of moisture, and the great bulk of our potatoes is grown in land that becomes too compact for the best development of tubers. With such soils the only rational thing to do is to undo the work of the rains that have fallen after the planting by making the ground loose once more. Roots will be sacrificed, but this may not be an evil. Planting early, our potatoes incline to make root growth too near the surface of the ground during the cold and wet weather usual to the month of May. These surface roots cannot be depended upon when heat and drouth come. It may be just as well that a deep cultivation is required to loosen the soil, as the destruction of these surface roots leads to deeper rooting. That is a point that does not require discussion here, the cultivation being a necessity for other reasons. It is my experience that this one deep cultivation, given when all plants are well above ground, can hardly be too close, if the soil is compact as a result of beating rains. A deep-running wheel-cultivator can be made to do fairly good work, and I hesitate to recommend any implement less modern. When it makes the soil loose in the row, where the tubers will be formed, nothing more can be desired. But very many of us are growing potatoes in heavier soil, and we are willing to give any sort of tillage that will show the most profitable results.

An Old-fashioned Way.—The point of the shovel of the cultivator should be run under the plants at this stage of growth, if the ground has settled firmly. Tubers cannot form in a hard soil. It is not now a question of root growth, but of the possibility of good physical condition of the soil in the hill. If the shovels of a wheel-cultivator, running on both sides of the plant, are pointed under the row, they will lift the plant out. A number of years ago we abandoned the use of the more modern implements for this one cultivation, and leaving them in the tool-house we returned to the use of the old-fashioned one-horse plow, having but a single stock. With a long and very narrow shovel, the plow could be held at such an angle

that the soil in the row under the plant could be shaken up. The method is slow and laborious. One man can cultivate only two and a half acres a day. But the work is rightly done, and potatoes are peculiarly responsive to right treatment. It is the soil in the row that interests the potato-grower. It should be loose naturally, if only such land were retentive of moisture. But if it were, it is not found on half the farms that should produce some potatoes. Dealing with land that compacts in heavy spring rains after the planting, we learn to make it loose in the row just as late in the period of crop growth as we dare. That time is when the plants are a few inches high. It is safe to go further and to say that if unusual weather conditions delay this work, and if the ground in the row is found very compact when the vines are even one foot high, it is better to sacrifice some root growth and make the soil loose enough for development of tubers than it is to go ahead without chance of crop. In such a case some crop may be gotten by throwing up loose soil in a ridge so that the potatoes may grow in it, but that calls for root-pruning anyway. However, it is an unfortunate condition of things that justifies such heroic treatment, and indicates failure to provide humus for the soil before planting. The only safe course is to make close land friable by drainage and by plowing down vegetable matter, and then give all deep and close tillage before the plants are many inches high.

The use of a single-shovel plow is a matter of arithmetic. If in the hands of a man who will use it faithfully and rightly it will do sufficiently better work than a more modern and rapid cultivator to pay, use it. Some growers find that it will; others think otherwise. If the soil is loose anyway, or if the workman is unwilling to hold the plow steady with point under the row, a wheel-cultivator is to be prefered.

Soil Moisture.—Professor King, in his valued book entitled "The Soil," says: "After the plant food has been prepared in the soil or in the air, it is useless until endowed with the possibilities of movement toward and through the living tissue. But water, through the action of capillarity and osmotic pressure, is the medium of transport by which the ash ingredients and the nitrogen of the soil are moved to the roots of plants, by which they are drifted into the sunshine of the laboratories in green leaves and bark, and from which they are again taken to their final place in the structure of the plant. Nor is this all, for water is itself a food substance used in large quantities by all plants of whatever sort. By its evaporation from the foliage of plants, it not only holds the temperature down within the normal range of the vital process there going on, but, because of this lowering of the temperature, it also hastens the osmotic flow of sap toward the leaves. The amount of water demanded by crops under

our methods of culture is very large." In Wisconsin, Professor King has found that 422 tons of water are required to produce one ton of dry matter in the potato.

Control of Moisture.—The first tillage in the potato field is to kill weeds and to break the crust. A single deep cultivation, close to the plants, is advisable for most soils, when all the plants are fully above ground, to insure looseness of the soil in the row. The tramping by horses and men in the middles makes a deep cultivation of the middles, with the long, narrow shovels of the wheel-cultivator, desirable. It should be given at the time of the deep working next the plants. All has now been done that can be done with cultivators to insure a crop, excepting the stirring of the surface to conserve moisture and prevent weed growth. But these surface stirrings are an important part of potato culture. Some Stations have conducted experiments to determine the number of cultivations that is best for potatoes, but a moment's consideration should show their lack of special value.

There is no certain number of times to cultivate potatoes. All depends upon the soil and season. It may pay to stir the soil twice in one week. It may not pay to stir it for ten days. When a crust is forming, or when the soil mulch is settling down solid so that moisture evidently is escaping, tillage is needed in the event of probable drouth. If abundant rain follows, the gain from the tillage can be only slight, but no one can foresee the weather conditions, and experience has demonstrated the profitableness of conserving the moisture we have in the soil.

The Source of Our Best Moisture.—Some people seem to have the impression that they should look to the clouds during the summer as the one source of moisture for growing crops. The fact is that the best source of supply of water for a summer crop is the rains of winter and early spring. I do not say that this is the chief source, but it is the best one because it is measurably within our control. The water that falls in the winter and spring, going down into the ground and coming back in time of drouth, is that with which we should most concern ourselves. It is our store at hand, and with the clouds we can not deal. The soil is a great sponge for the holding of water. When it is deeply plowed and full of humus, it drinks up the water from snows and rains, and that water passes down into the subsoil. One of the chief offices of tillage is to make soil receptive of rainfall and retentive of moisture. The water in the soil is moving all the time. When there is more of it at the surface than there is below, the water descends. This is observable immediately after a summer shower when we find that the plant roots remain unmoistened for a time, but know that the next morning will find the soil about them made darker by the moisture that has descended. On

the other hand, when the drying wind is carrying away the moisture at the surface of the field, the water below is rising to equalize conditions. As more moisture is carried away by the air, more rises to replace it, and there is constant loss of water—constant draft upon the great reservoir created by the rains of past months.

The Mulch.—It has never been easy for me to accept the statements of scientists concerning the problems arising in farming unless the everyday facts in the field appear to sustain them. Some young readers may share in this disposition to want evidence, and the control of soil moisture is so important that a few experiments are suggested.

In a dry spring, place a straw mulch about some berry plants, and leave the ground bare about others. Mulch one-half of a pansy-bed, and leave the other half bare. In a dry July, mulch a few rows of potatoes with litter, and leave a few rows untouched. Note the difference in results, bearing in mind that no more water has fallen on the mulched plats than on those left untouched. The difference in the moisture content, so apparent upon examination, is due to the arrest of evaporation of soil moisture in the mulched land, and to its escape from a soil that has no mulch and is left bare and compact.

Soil for Mulching.—It is impracticable to use any foreign material for mulching our potato fields, but we have learned that a mulch of soil may be made to serve the purpose of retaining the water in the ground. Knowing that the water tends to rise during drouth to replace that which has escaped into the air, our aim is to interpose something between the rising moisture and the hot air that would carry it away. The water rises in a compact material, but is checked by one more porous. Straw makes a good check, but experience has taught that two inches of loose soil on top of the compact portion also is a highly effective check. Its pores have been broken up by stirring so that water does not pass up through it readily, and it lies as a blanket, guarding the water from the wind and sun.

Another test may be suggested at this point with profit. After a drouth of several weeks duration, take a post-hole digger into a field that has had careful surface cultivation, and thus has had its moisture retained by the soil mulch, and dig a hole three feet deep, noting the degree of moisture found. Then go to an adjoining plat that has lain uncultivated for any reason,—pasture land, a fence-row, or preferably, a piece of bare land—and dig down three feet, if the dryness of that land will permit. Again note the degree of moisture found. If the land has been bare, there has been no draft upon it by plants which transpire great quantities of water through the leaves, as in the potato field, and yet it will be found much dryer than the field that has been properly tilled and has furnished large quantities of water to growing plants. The top soil can be made into

a mulch that does much good in a dry period, and the leading object of cultivation in the potato field, after the one deep tillage described, is the creation of this earth blanket. Do not decrease depth of cultivation gradually; do it at once. The one cultivation was to overcome the ill-effects of packing rains on a somewhat clayey soil after planting; later cultivations are merely to keep the surface stirred, and all the soil below such a mulch should be left alone for the use of plant roots. It is their feeding-ground, and they should be left undisturbed in it.

Kinds of Cultivators.—The implements required in modern tillage of the soil demand a considerable expenditure of money. It is not easy to determine the limit to profitable investment in them. Some farmers buy too many, having too little use for some implements to make the investment pay. But I think that a far greater number fail to buy as freely as they would find profitable. It is sure that planting should not be done unless good tillage can be given, and we must give that tillage as cheaply as possible. Human labor is high-priced labor, and the implement that saves time is earning in that degree its cost. Some crops may wait for cultivation without serious injury to them, but the potato is not one of these. It is a costly crop, requiring good soil and expensive seed, and its returns per acre are relatively large when a good yield for the season is gotten. There are few crops that repay care any better. Implements for rapid work pay for themselves more quickly in the potato field than they could in fields growing crops of less value per acre. It is my experience that a seeming surplus of horse-power and of tillage implements is desirable. A cultivation at the right time in a bad season may be worth a big sum, and no one should plant an acreage requiring the steady employment of all teams and cultivators. If he does, some bad weather will bring failure of a part of his crop.

For rapid cultivation after planting, and until the plants are several inches high, the weeder is an excellent tool. In loose soils it does entirely satisfactory work when used in time. The time to kill weeds is before they get above the surface, or at least before they form any roots deeper than the weeder teeth go. The time to break a crust on the surface of a field is before the crust hardens. But there are clay soils that pack and become hard after rains before the ground is dry enough for cultivation. For such land the weeder is needed to stir the soil in the row, and to level it, after the ground has been stirred by a heavier implement. It does not do satisfactory work among loose stones, but elsewhere the horse-weeder can be used with profit at certain times.

The two-horse wheel-cultivator is found on most farms. It should have narrow shovels, at least three on a side, and should be so constructed that they can run deep when desired and can be used for sur-

face work. Where only surface work is wanted, the spring-tooth is excellent. The wheel-cultivator is used until the vines fill much of the middles, and then the one-horse cultivator comes into use. The latter implement, going once in the middle, cannot do as good work as the two-horse cultivator while plants are small. It does not give the close hoeing to each hill that is necessary in good work. But when the vines shade the row and close work is no longer possible, the one-horse implement, with wheel to regulate depth, is nearly perfect. The object of all this later cultivation is to preserve moisture by keeping the surface two-inches of the soil loose, and care must be exercised that the plant roots in the moist soil below the mulch are not torn by the cultivator hoes. The thing to do is to give the potato plants a chance to use the food in the soil. The ground has been made loose as late in the season as is consistent with root growth, and our business then is to keep the moisture in that ground, and to let the plant roots use it in storing up food for themselves. Carelessness in matter of depth of late cultivating may rob a plant of much of its ability to gather food.

Laying Potatoes By.—Formerly we heard much about "laying potatoes by." This work then consisted of running a very broad single shovel through the middle, throwing the soil upon the row and ridging it. When this had been done, cultivation was at an end, because the ground was up in ridges and nothing more could be done. Nowadays, the potatoes "lay" themselves "by" when they make such a growth of vine that they do their own mulching of the field, and we cannot get a cultivator through the middles. The only time to cease tillage of potatoes is when the vines cover the ground. If the planting has been deep, in soil made properly loose by use of humus, the potatoes form under the dry soil mulch, and they do not come to the surface no matter how flat it is. When a crust is formed in the field by a rain, the right thing is to break it before it hardens, if the vines are not down upon it, preventing such work. The period of blooming has naught to do with determining the time to cease stirring the surface soil, except that one should have plants by that time so large that little more tillage can be given.

In all this we are assuming that the potato rows should not be ridged. Let us reason together. We know that the sweet potato is the opposite of the white potato in that it wants heat and not a great degree of moisture. Hence we learned to make ridges for them. The ridge increases the area of surface exposed to the hot air, and in the north that suits the heat-loving plant. The white potato wants the cold of the extreme northern States, as we know from its productiveness in such sections of our country. It needs a cool soil for its roots, and hence we learn to keep our land cool and moist by exposing no more of it to the sun's rays than is necessary—

by keeping the potato roots deep under a flat surface having an earth mulch.

But there are instances in which it is best to throw up loose earth in the row. If ground is heavy and wet, potatoes will do no good down in it. If there is reason for planting such land, it is best to put the seed near the surface, and to ridge the ground. The tubers are fed from the joints in the stem, and the extra soil banked up increases the extent of that part of the plant that puts forth the underground stems, while the looseness of the newly-made ridge lets the potatoes develop. While insisting on the profitableness of having the main body of the soil drained and loose, so that the plants can have the best conditions, I do not urge deep planting and level cultivation for ground of other character. It is better to plant shallow and to ridge when the soil is heavy and wet.

This conclusion, based upon personal experience, is substantiated by Station experiments. The Cornell Station says that "level culture is preferable to ridge or hill culture for conserving moisture. Ridges should only be used when the object is to relieve the soil of moisture, as in low, damp fields."

It may be added that ridging promotes earliness in a cold soil, and may be often desirable to the market gardener.

Level culture is at the best a relative term. We never leave ground absolutely level when cultivation stops. Some soil is worked into the row, and the tramping of horses depresses the middles. A difference of two or even three inches between the level of the middles and that of the row is very common where the aim is to practice level culture. It would be better entirely level, but the cultivation close to the plants and the one deep plowing in the middles even with the narrowest shovels make slight ridging. The nearer level the ground, the more benefit is derived from light rains. Level cultivation is the rational kind for land that is adapted to the crop, and the nearer we get our soils in prime physical condition for the crop, the less necessity there is of any root pruning, any surface planting or any ridging to furnish a covering for the tubers.

The Hand-Hoe.—It is our desire that this discussion of potato culture should fall into the hands of many persons who grow potatoes on a small scale in town lots and in home truck patches. They may not have the use of weeders, wheel-cultivators and other implements of the potato farm. For their benefit the statement is made here that while these implements do good work, and are essential to the large grower, no one implement has even been made that is superior to a hand-hoe when in the hands of a man who knows how to use it. The work may be too slow for large fields in most potato sections, labor not being available for its use; but the man who is able to give potato plants thorough hand-hoeing in the row may rest as-

sured that his tillage is as good as any that can be given. We like to boast of our progress, but no costly implement upon the market can stir the soil next to a potato plant as satisfactorily as a hoe in the hands of a skillful man. Our progress has been in speed and in reduction of expense, but not in any excellence of the cultivation over the hand-hoe for work in the row between the drilled plants. I do not recommend its use in the field on account of the cost of labor, though I have been led in recent years to give one hand-hoeing to all potatoes in clayey soil. The expense of $2.00 an acre thus incurred has appeared to be much less than the increased receipts per acre due to the extra tillage. But the matter is brought up for recommendation only to those who may lack a complete outfit of implements, and feel at a disadvantage in trying to grow only a few acres, or less, a year.

Excepting the use of the hoe to break the crust and kill weeds in the hill—work done in the field with the weeder and other cultivators—the object of a thorough working with long, narrow-bladed hoes is to loosen the ground between the plants soon after the one close, deep cultivation has been given. The blade should be made from three-sixteenths steel, eight inches long and three and one-half inches wide. With a heavy eye and handle, it is not a light implement. The blade is long, so that it will easily reach across the narrow ridge left by the cultivator and down as deep as the ground should be made loose. It is narrow in order that too much soil may not be moved. Set at an angle of sixty degrees to the handle, a single stroke by side of the plant does the needed work, and two strokes complete the hoeing for the hill. A good workman will go over three-quarters of an acre a day, and in a heavy soil such a working may double the net profit from the crop.

Danger in Wet Seasons.—It is a common saying that a dry June is good for a corn crop. One reason is that dry weather at that time causes the corn plants to root deeply. When the weather is wet early in the season, potato plants form their roots too near the surface, and do not develop a system of roots sufficiently deep to serve them well when a drouth follows the wet weather. A reference to personal experience may be useful here. In 1901 we had excessive rainfall until the middle of June, and then a drouth set in so seriously that the local price of potatoes remained at ninety cents a bushel throughout the fall. Some fields of potatoes were not worth harvesting. Early in June I noticed that in one small field of six acres the roots of the potatoes were forming thickly in the surface soil in the row. In the middles one deep cultivation had let them work farther down. In the rows these roots were within a half inch of the top of the ground, seeking air during the incessant wet weather. The vines were then over one foot high, and the outlook was discouraging be-

cause drouth was most probable after so much rain, and these roots upon which the plants were depending were too near the surface to be of any service when the weather should turn dry and cultivation had ceased on account of the size of the vines. I had advocated and practiced shallow tillage when potato plants became a few inches high, but the conditions were so unusual that, as soon as the ground would permit, the long-bladed hoes were put to use breaking off the roots at the sides of the plants and opening up the soil to the air. It was radical work, and some slight wilting of the vines was observable. But so sure did it seem that a drouth would bring crop failure if deeper rooting were not gotten and loose soil provided, that the work was persisted in, and while the yield was not very large, the receipts were $118.00 per acre because fields left untouched could not make any growth when the drouth came. In this season—1902—the rains did not fail us for the early crop, but the same treatment certainly was not a detriment, as the yield in the same field is 250 bushels per acre. In the rather compact soil of this land a part of the yield is fairly attributable to the loosening of the soil, given by these hoes, that was needed to overcome the packing effect of rains. But this slow and old-fashioned way of giving tillage is commended chiefly to those who may believe they should not plant any potatoes because they can not buy all the implements of tillage.

Late Planting.—The details of early planting have been given because such planting is best in most sections of the belt for which this treatise is prepared. But the grower may find it better to get the growth after midsummer rather than before it. If this be the case, then the planting should be late enough to delay the development of tubers until early autumn. The cool nights of fall are even more favorable to potatoes than the early season of the year, provided moisture is present. If the planting is late, the culture is somewhat different. There is less danger of having a packed soil after planting and more danger of drouth. The work of preparing the ground for planting should be done thoroughly. The covering when planted may be deeper, and a close plowing under the plants is less likely to be necessary.

Thinning.—The price of "seconds" is so much less than that of the first grade that there is constant temptation to use small potatoes for planting. The small tuber is very apt to send up more stalks, giving more setts than are wanted in a hill. Some growers have tried to correct this tendency by clipping off the tip end that has so many eyes, but this has not been done with profit, as a rule. The matter has been the subject of Experiment Station tests, and it is fairly definitely settled that such clipping does not pay. Other growers have tried thinning. Theoretically this should give good results, and there are extensive growers who practice it satisfactorily to

themselves. But the evidence in its favor does not justify recommendation of the practice. The work must be done when the plants are small. It is very laborious, and there is always danger of disturbing the seed pieces or other stalks. For these reasons it is better to control the number of stalks by reducing the number of eyes planted rather than to depend upon thinning. The small potato that sends four to six stalks to the surface does not send as thrifty ones as the section of a large tuber that has the weight of the small tuber and only two eyes. The addition in cost due to the use of larger tubers is justified by the yield in most years.

Vine pruning has been tested by one Station, and no advantages were secured thereby.

INSECT FOES AND REMEDIES.

The potato has a number of serious insect foes. It is a common thing to hear growers lament that disease and insect attacks make their business hazardous, but I am sure that the progressive, energetic producer has no better friends than these so-called foes. The staple crop that is easy of production affords a minimum of profit because production is heavy. The most careless can secure yields, and the supply exceeds the demand. This would be notably true of the potato if there were no enemies of the crop—insects or disease. The best products for the live farmer are those requiring the most skill and care in their production, as competition is limited by the conditions necessary to success. I do not care to assert that the foes of the potato are desirable, as they make life harder for the inefficient who must live, but clearly they do help the energetic.

As the potato crop becomes old in any section of the country, the foes to it multiply. This is true of insects, and especially so of diseases. As soils grow old and are permitted to become deficient in humus so that drouth cannot be withstood well, and as disease and insects increase, the tendency in potato production is to shift its center to newer and more remote land.

In the part of this treatise dealing with this subject, the mass of matter contributed by our Experiment Station scientists is freely drawn upon, selection being guided by personal observation and experience in the field only so far as they come to a practical grower of potatoes.

The Colorado Beetle.—Probably the best known insect attacking the potato is the Colorado beetle (*Doryphora decemlineata.*) "It was first brought to notice," says Professor Geo. C. Butz, "about the year 1856. In 1859, it was found in the potato fields of the settlers of Kansas. In 1861, it was in Iowa, and in 1862, it appeared in southwestern Wisconsin. It crossed the Mississippi river into Illinois in 1864.

It was in Michigan and Indiana in 1867, Ohio in 1868, and Pennsylvania in 1870. It moved eastward at the rate of about fifty miles a year for a number of years, but later it traveled more rapidly. It is reported to have reached the Atlantic coast about 1874, and Nova Scotia about 1882. When it reached the Atlantic coast, it had traveled 1,500 miles in sixteen years, and nearly a thousand miles more the next eight years in its march to Nova Scotia.

"These insects have great power of endurance. They will walk for great distances in search of food and, by direct experiment, they are known to have lived thirty days without food. In the spring, the beetles appear along with the first growth of potatoes, and while they devour some of the foliage of the potato plants, the damage is slight as compared with the destruction caused by the larvae of the succeeding brood. These early beetles lay their eggs upon the leaves of the potato. We may find the orange-colored eggs in masses, varying from a dozen to fifty, closely placed upon the under side of the potato leaf. It is said that a single female may lay as many as one thousand eggs in its lifetime. The eggs are sometimes found upon leaves of grass, smartweed, or other plants in the potato field. They hatch about a week later into peculiar looking hunchbacked grubs or larvae of a reddish color, with markings of black spots in double rows on each side. The larvae walk to the tenderest part of the plant and there feed very rapidly, increasing in size by successive moults until they are full grown. The length of time in the larval state is fifteen to twenty days, when they leave the plant and go into the ground a few inches below the surface and there pupate in a cell of earth. In about ten days later they emerge as perfect adults, which go in search of the plants again to lay eggs. There are from two to four annual broods in this country, varying with the latitude."

EFFECTIVE REMEDIES.

Any serious damage to a crop by this beetle is unnecessary. The only possible exceptions to this rule are when the beetles in the spring appear in vast numbers upon plants as they are coming up, and when the beetles of the second brood cross from the field of a careless farmer into one's own field.

In the first instance, resort may be had to hand-picking of the field, if reasonably small. Attempts to poison are not to be advised on account of the tenderness of the new plant foilage and the hardiness of the old beetle. The most feasible plan is to have the plants down in furrows, as they will be when the covering has been made shallow, and then to fill the furrows with loose soil. This gives the plants time for gaining more vigor, and for some scat-

tering of the beetles. When the plants appear again, if the plague of beetles continues to threaten their destruction, a ridge of soil may be thrown over the rows. It will do no injury, and when the plants emerge again a weeder should be used to level the land. By this time the thriftiness of the plants will usually put them beyond serious danger so far as the brood of old beetles is concerned.

The grower then has opportunity of mastery, and if he succeeds as thoroughly in destroying the larvae of the first brood as he should do, there will be no second brood to do injury late in the summer. The one practical method of killing the larvae or grubs—the "young bugs"—is by poisoning. The Maine Station made experiments with various insecticides and reached the conclusions that "in fighting the Colorado potato beetle no adequate substitute for arsenical poisons has yet been found." The efforts are now limited to finding cheaper or more effective compounds of arsenic than Paris green. There are many preparations upon the market, some of which are good and some are poor. A good preparation has strength, remains in suspension in water well, and is not soluble, as is white arsenic, which may burn the foliage. Where a high-grade article of Paris green can be bought at a fair price, it may be safely recommended. Where there is no state inspection of this poison, the buyer should test his purchase before making application to the field. A few early-hatched grubs are sure to appear, and within a few hours the relative strength of the poison may be learned.

Arsenites in Water.—The most common way of applying arsenites is in water, four to six ounces of Paris green being used in fifty gallons of water. The former amount is sufficient for very young grubs, but the latter should be used if by any chance the grubs are half-grown when the application is made. It is a mistake to delay applying the poison until any grubs are half-grown. This is often done in the plea that all should be hatched out so that one application will serve. But when any of the grubs have reached such a stage of growth, some will not be killed by the poison. They are scattered over the vines, and find some leaves sufficiently free from poison to escape death, and these become the beetles that give us the second brood of grubs which often do much harm. More than this, the eating of the leaves checks the vigor of the plants. The arsenite should be applied when the grubs appear, and if it does not adhere to the vines until all are hatched, a second application should be made. The arsenite should be thoroughly mixed with water in a large bottle, and then emptied into the barrel.

Sprayers.—Devices for applying insecticides in liquid form are many. It is my experience that the knapsack sprayer is better adapted to gardens and small fields than to an extensive acreage, but it does good, thorough work. The spraying apparatus that covers

four rows at a time, having a nozzle for each row, I have discarded because the work done by it is not thorough enough. There may be improvements in it, but the probability is that human direction of the nozzle as it plays upon each hill will always be desirable. The barrel pump in a one-horse cart, carrying two hose and nozzles under direction of two men, secures thoroughness.

Applying Arsenites Dry.—The grower of potatoes on a small scale may not have even a knapsack sprayer, and primarily for his benefit I describe a method of applying Paris green in dry form that makes the poison more effective than it can be made in liquid form. The method will not commend itself to many extensive growers because it is relatively slow, and yet I have learned to leave in the tool-house all modern devices for applying poison to potato vines and to use this rather primitive method in large fields for the simple reason that it insures the death of all the grubs, and we no longer have any second brood late in summer to do injury.

Observation shows that the young grubs go to the buds of the plant when they leave the leaf on which they hatched. It is there that they find the tender fibre suited to their taste. A slight amount of poison kills quickly when taken at this age. It is right in the bud, and well down in it, that the poison should be placed, and there some of it should remain throughout the hatching season. These two things are secured by using a sifting can that drops the poison where wanted, and by having the poison mixed with some material that will form a paste in the first dew, and adhere to the leaves. Air-guns are more speedy, and they clean the vines of the grubs that are present in fair degree, but they do not leave a body of poison in the buds of the plant that will remain for the next lot of tiny grubs that are hatched. Several applications with air-guns or bellows are required, and these cannot be made when much air is stirring. Often the grubs make their appearance rapidly in threatening weather when there is wind and showers, and arsenites in water, or in dry form without a diluent that will stick, do not do effective work.

The Sifting Can.—The device recommended to the small grower is made of a tin fruit can, with a handle attached. Twenty or thirty small holes should be punched into the bottom of the can with an awl. Then near the top a slit two inches long should be cut in the side, and this bi-sected by another slit. Pulling the four flaps outward, the end of a handle three feet long should be thrust through at such an angle that it will be near the bottom when it strikes the opposite side of the can. A nail is driven through the tin into the end of the handle, and the points of the four flaps of tin are tacked to the wood. No cover is needed. This sifter is carried in one hand, and is jarred by a stick carried in the other hand, when the can is

held over the bud of the plant. There is no reason for coating the entire plant if the work is done at the right time.

The arsenite should be mixed with a material that becomes sticky when wet. There is nothing better than wheat flour, and a damaged or low grade lot usually can be bought for a small sum. The mixture should be strong—one pound of Paris green to sixteen pounds of flour—which is a sufficient amount for treatment of an acre of rather large vines. When the tops are small, and there are few branches, a less amount is sufficient, and an active boy can make the application to two acres in a day.

Lime is generally used as a diluent when applying arsenites in a dry form, but it is undesirable because it will not hold the poison on the vines during a rain, while flour will do so if set by a dew or mist. There are seasons in which a second treatment of this mixture becomes necessary, but they are the exception. If cold weather protracts the time of hatching, or if the rains are very heavy, one treatment may be found insufficient, but our experience is such that we expect one application, properly made, to suffice, and the expense per acre seems slight when it affords immunity from this pest for the season. The secret of success with it lies in having the mixture strong, and placing it where all the grubs go soon after hatching. It lodges in the new leaves of the stalk, and the grubs that hatch later find it and drop off unnoticed. I am commending the plan only to those who have a small acreage, knowing that most growers on an extensive scale will prefer the sprayers on account of the rapidity of the work. When the Bordeaux mixture is being applied for blight, the arsenite for the potato beetles or grubs is put into it.

The arsenite should be dissolved in a small amount of water before it is added to Bordeaux mixture. A convenient way is to use a large bottle so that the water and arsenite can be thoroughly agitated.

Parasitic Enemies of the Beetle.—There is constant increase in the enemies of the Colorado beetle, and this is in accordance with the law of nature that maintains a sort of balance in the insect world. When any one species increases out of due proportion, a natural check of some sort is usually provided. Several species of insects prey upon the eggs and upon the grubs of the beetle. In some years they are so numerous in sections of the country that no grubs can reach maturity. This was observable in the season of 1902 in my own fields, rendering any application of arsenites unnecessary. Another season these enemies of the beetle may be less numerous here, and we should not expect entire immunity from attacks of the Colorado beetle through such agencies, but it is probable that there will be increase of these insects.

The Flea Beetle.—An immense amount of injury is done to the

potato crop by the flea beetle. It is unnoticed by some growers while at work, although the effect is soon observed in a loss of dark color in the foliage and an appearance of unthriftiness. It is the insect that punctures the leaves, gnawing innumerable holes through them. Several species attack the potato, the so-called "cucumber flea beetle." (*Haltica cucumeris*) being most observed in the north. This insect is minute, and easily escapes detection by those unacquainted with its work and habits. Usually it attacks potatoes at a critical period of growth, and a close observer will soon discover the very small holes or yellow spots in the foliage indicating its presence. Many insecticides have been used with little success,and it remained for the Vermont Station to call public attention to the merit of Bordeaux mixture as a repellant. To this, Paris green should be added at the rate of six ounces to a barrel of the mixture, and the spraying must be most thorough. Arsenites alone are not effective, and the spraying with Bordeaux mixture and an arsenite will not give the desired results unless it is very thorough and persistent. Probably no other one enemy does as much to weaken the vitality and lower the yield of potato plants as these minute jumping beetles, and spraying against their attacks is urged even when the spraying is not needed to prevent blight or the Colorado beetle.

Where a grower has a very small acreage and has no equipment of sprayers, he may have partial success in repelling the flea beetle by dusting the vines with lime or tobacco dust when they are wet with dew.

A Cause of Pimply Potatoes.—In this place attention is called to a pimply condition of the potato that sometimes makes it very undesirable in market. The Station at Geneva has done good work in investigation of this trouble, and in Bulletin No. 113 it summarizes its results as follows: "The cause of the trouble known as 'pimply' potatoes has been definitely determined. Minute, slender white grubs have been found boring into the tubers, roots and root-stock of the potato during the growing season. The pupae of these grubs have been found in connection with them. The grubs and the pupae have been proven to be the early stages of the common cucumber flea beetle, a very injurious insect, the life history of which has heretofore been imperfectly known. The wound made by the boring of the grub results in the formation of a 'sliver,' but a pimple may or may not be produced, depending, probably, upon the state of growth of the tuber at the time the wound is made. The most practical method of preventing the pimply potato trouble is to protect the foliage against the attacks of flea beetles by thorough spraying with the Bordeaux mixture." Additional reason is thus afforded for fighting the flea beetle.

The Blister Beetle.—The "old-fashioned potato bug" is an old ac-

quaintance. There are four or five species of these beetles, and I know of no more disastrous enemy when they come in great numbers, because they are not easily vanquished. When Paris green is applied, it seems to have little effect. The only redeeming feature possessed by these beetles is that they do not raise their families on the plants, and we do not have the larvae, as well as the beetles, to fight, as in the case of the Colorado beetle. Many remedies have been tried. When the field is small and one does not have the fear of his neighbor before his eyes, it is entirely feasible to drive the beetles out of the patch, threshing the ground behind them with bushes, and letting them go in the general direction they were taking when they entered the patch. When found entering the side of a field, it has been recommended that straw be scattered along the edge, and the beetles be driven into it and then burned. This is a remedy that works at times, and fails utterly at other times. The only fairly satisfactory way of fighting this pest is by thorough coating of the vines with Bordeaux mixture and Paris green. The arsenite is put in on the principle that nothing should be left undone in the fight, but the effectiveness of the remedy lies chiefly in the repellant power of the mixture.

Potato Stalk-Borer (*Trichobaris trinotata*).—As potato sections grow older, there is increase of the stalk-borer which causes a premature wilting and drying of the vines. Dr. T. W. Harris records its presence at Germantown, Pa., in 1849, and says: "In many fields in the neighborhood of Germantown every stem was found to be infested by these insects, causing the premature decay of the vines and giving them the appearance of having been scalded." Dr. Halstead, of the New Jersey Station, gives, in Bulletin No. 109, the following life history: "The beetles appear in the fields early in spring, and they live well into June. They are ashen-gray, oval, with a black beak or snout, and about one-quarter inch in length. At the base of the elytra or wing-covers are three small, shining black dots, which give the insect its specific name. This beetle punctures the stem of the potato near the ground with its slender beak, and in the hole so made deposits an oval, soft, white egg. From this there hatches in a short time thereafter a small white larva with a brown head. This grows apace, eating in the center of the vine, either in the trunk or in one of the large branches, and attains its growth at any time between August first and September first. It is then from one-third to one-half of an inch in length, dirty white or a little yellowish with a yellowish-brown, horny head, and without perceptible legs. It lies in the stalk in a slightly curved or curled position and at some time about the middle of August constructs a cocoon of chips and fibres in which it changes to a white pupa, in which all the organs of the future beetle are distinctly visible. These cocoons may be in

any part of the stalk, but in small plants are usually at or near the surface of the ground, where the tissue of the vine is hardest, and the chances of retaining the form unaltered through the winter are greatest. The beetles mature in August and September, and remain in the vines all winter."

Concerning remedies, he says: "It is at once obvious that insecticides are of no use in this case, because the larva is an internal feeder; but its habit of passing the winter in the dead vines gives us complete control over it. Simply rake up and burn all the vines after the crop is gathered, and with them the entire brood of insects will also be destroyed. Besides this, war should be waged against the Jimpson weed and the horse-nettle, as otherwise a considerable number of specimens will be likely to survive. If the presence of larvae is noticed in the field, the only thing to be done is to stimulate plant growth to the utmost by the application of appropriate and readily soluble fertilizers, that the vines may be enabled to mature the crop despite the attacks of the insects."

White Grub.—The unsightly appearance of potatoes is due oftentimes to the grubs of the May beetle. Growers seek a direct remedy, believing that the application of some material to the soil should destroy them. Station and farm tests have been very thorough in this matter, and it may be stated confidently that no treatment of the soil with insecticides will be effective unless the insecticide is used at very heavy expense and in such large quantities that crops would be destroyed. It is common to read of success from applications of common salt, kainit and other materials, but the disappearance of the grubs was due not to the application given but to the fact that the time had come for transformation to beetles. A little study of the life history of the May beetle will make this fact plainer, and will enable the grower to evade loss in some degree. The beetles appear in May or early June, living on the foliage of various kinds of trees. Their eggs are deposited only among the roots of grass, and the grubs hatch in July or August. These grubs continue in the soil for two or two and a half years, when they change into a dormant form, and appear as beetles three years from time the eggs were deposited. The grubs in the first autumn of their lives are small, and the injury to crops by them is usually slight. In their second summer they are voracious feeders, and likewise in their third summer. I believe that they sometimes continue to eat until late fall the third year, not changing to dormant form until spring. It is quite common to find two broods of the May beetle in the same place, and there may be three, giving grubs of all ages and sizes. When such is the case, the ground becomes practically worthless, if each brood of beetles is large. Usually there is only one brood that is important, and this gives a chance for some evasion of their injury.

The fields under cultivation the year the beetles appear escape much infestation by grubs, and sod land broken the next spring, when the grubs are small, may be cultivated in corn without much danger. Winter plowing is recommended, and has a degree of effectiveness in a cold winter. Cold, heavy rains, during the month the beetles should appear cause the death of many.

The right thing to do in respect to white grubs is to watch for them at time of plowing the ground, and if they abound, the potato crop should be omitted. If planting is done, early varieties should be used, and the crop should be dug as soon as it is ready for marketing. It is idle to plant a crop like potatoes to be eaten by insects we can not fight effectively, and the white grub belongs to his class.

FUNGOUS DISEASES AND REMEDIES.

Probably the most serious fungous diseases of the potato are classified as blights. Throughout the potato belt of this country, but chiefly in the southern half of the main belt, the Early Blight (*Macrosporium solani*) is restricting yields enormously. In the northern half of the belt, and farther south in cold, wet seasons, the Late Blight (*Phytophthora infestans*) has caused great loss. Much confusion exists in the minds of many growers concerning the character of these blights. The Cornell Station has had unusual success in control of the blights by spraying with the Bordeaux mixture. I incorporate in this treatise its descriptions of Early Blight and Late Blight, and an account of the method employed at Cornell in making the Bordeaux mixture, reserving the privilege of some comment on one or two points in which my own experience in spraying does not accord fully with that of the Station. The quotations are made from Bulletin No. 140, and are as follows:

"Early Blight.—As the name indicates, this usually makes its appearance early in the season and upon early varieties of potatoes. Hot, dry weather favors its growth, and it is usually most severe in its attacks where the potatoes are planted on dry soils. It will, however, make its appearance when the weather is moderately cool. Whenever the potato foliage has been injured by the flea-beetles it seems to be predisposed to attacks of the early blight, the spores finding a favorable resting spot on the injured places of the leaf. Any condition or treatment which has produced a weakening of the plant causes it to be more likely to attacks of blight. Strong, healthy growing plants may be entirely free from attack, while plants which have for any reason been checked in their growth fall an easy prey to the disease. While this early blight does not cause the po-

tatoes to rot, it so injures the foliage that the growth is checked long before maturity and instead of the potatoes being full grown they are undersized and immature. It is very possible for the early blight to attack a field of potatoes and its presence never be recognized by the farmer, it being mistaken for a case of early maturity. This may be the reason the early blight fails to attract as much attention as the late blight and it no doubt does far more damage than is generally accredited to it.

"It is difficult to describe its characteristics definitely as so many variations occur, and as it frequently is confounded with the late blight, it being sometimes scarcely possible to recognize the difference without the aid of a glass. It usually makes its appearance during the latter part of June or during July and may even appear as late as August.

"The parts of the foilage first attacked are likely to be the edges of the leaves, the disease manifesting itself in several places on the same leaf, and affected area as first being circular in outline. The color of the foliage changes from a green to a russet or dark brown or even black and the edges curl as the tissue dies. A distinguishing characteristic of the early blight is the general appearance of the tissue of the leaf beyond the most seriously affected portions. Instead of retaining the green color of healthy foliage, it assumes a yellowish appearance similar to that of matured plants, this premature ripening probably being caused by the general weakening of the plant. This appearance no doubt is the cause of the general supposition that when potatoes are effected with the early blight the death of the vines is due to natural causes and is simply a case of early ripening when in reality it is premature and due to the blight.

"One remedy for early blight will have been suggested by what has been said regarding the predisposing causes. It attacks plants which have been for some cause weakened or injured. Treatment, then, should begin with the preparation of the land. Deep plowing to furnish an adequate feeding ground and a reservoir for moisture, seed cut in pieces of good size, the surface soil crust broken with a harrow before plants are up and then thorough tillage and protection from both the flea-beetles and the Colorado beetles. If the plants are kept in vigorous growth, they will largely possess immunity to the early blight.

"Bordeaux mixture is the standard remedy for this as well as other fungous diseases. If it has used in early spring in combating the flea-beetles, and if when Paris green is used to kill the Colorado potato-beetles it is applied in Bordeaux mixture, there is but slight chance that the early blight will appear. The treatment in the manner above described serves a double purpose. The foliage is kept vigorous and healthy, free from attacks of the insect pests, and this

alone lessens the liability of attack by the blight as the Bordeaux mixture forms a coating of copper over the foliage thus protecting it."

"Late Blight.—This is a fungous disease which is responsible for the potato rot of the present season in New York State. Its appearance is well known and it has attracted far more attention than has the early blight. The widespread famine in Ireland in 1846, was largely due to the fact that the potato crop was destroyed by the late blight. At the present time another famine is threatening in Ireland and due to the same cause. In our own country while the disaster is not so great yet the loss this year has been enormous, and it is a loss which might have been prevented.

"This disease in an aggravated form is not difficult to recognize as it may be perceived both by its appearance and disagreeable odor which comes at first from the foliage and later from the decayed tubers.

"The fungus causing the common potato rot is an old offender. It was undoubtedly introduced into Europe with some of the early importations of the potato, and has in certain years proved so destructive that famines have resulted from the entire loss of the potato crop. Such occurences eventually lead to thorough study of the organism. As early as 1846, the fungus causing the trouble was very carefully described in an English publication, and since that time other observers have given the disease much attention. It has spread to many regions in which potatoes are extensively grown, so that both scientists and farmers are very familiar with many of its characteristics.

"The most interesting feature connected with the fungus is undoubtedly the wonderful energy which it exhibits, under favorable conditions, in the destruction of the potato plants. It sometimes spreads with such rapidity that a crop may be ruined in one or two days; and unfavorable conditions, or the total destruction of the plants, formerly appeared to be the only effectual agents in preventing or checking the spread of the dreaded disease. This rapid decay of both the foliage and tubers is perhaps the most distinctive of these characters which are commonly brought forward for the identification of the disease. It is almost invariably accompanied by a strong, disagreeable odor which is easily recognized by all who have once experienced it. When large fields have been attacked, the smell is particularly strong; it then arises entirely from the foliage, and is not produced by the tubers.

"The conditions which favor such rapid decay are, as a rule, not generally present throughout this State. The fungus makes its most rapid growth in a temperature of about seventy degrees Fahrenheit, when much moisture is present in the atmosphere. Cloudy

days, with occasional showers, and a close damp air are especially favorable to its growth; and if such periods occur during August and September, the disease may appear at any time. But, on the contrary, if the season is dry and hot the fungus is unable to develop, and little or no injury of this nature can appear. It is for this reason that the potato rot is not a regular visitor in most parts of the State, but is more generally confined to certain localities. These are found in the more northern potato districts, in the regions near the sea coast, and in some parts which have a high altitude. In such places the fungus may develop regularly every year, and the severity of the attack will be modified chiefly by abnormal atmospheric conditions.

"The manner in which the germ tube of a spore penetrates the tissues is interesting. It is now generally believed that the ends of the tube secrete a ferment which has the power of dissolving the walls of the cells comprising the outer layer of leaf tissue. 'When such an opening has been made, the small thread of the parasite passes through the outer layer, enters an intercellular space, and then rapidly extends its thread-like growth between neighboring cells, drawing its nourishment by means of minute suckers which penetrate the cell walls.' The entire destruction of the leaf may be accomplished. A stoma, or breathing pore, may also serve as a point of entrance.

"The rapidity with which the fungus advances within the leaf tissues depends very largely upon external conditions, and the appearances of the affected parts is also modified to a very considerable extent. Unfavorable conditions frequently render the identification of the parasite a different matter without the aid of a glass, but under such circumstances the disease may be fairly widespread and still cause little injury. In serious attacks, however, many characteristic symptoms may be easily recognized.

"The following points should be noted: The diseased areas are of considerable extent, and may be started in any part of the leaf, but the edges appear to suffer more from new infection than the more central portions of the leaflets. This is probably due to the fact that in the case of rains these portions remain moist for a longer period than the center, since the water drains to the lower parts of the leaflets, and collect there in the form of drops of greater or less size. It is to be expected that under such conditions a fungus could gain an entrance more easily than in drier places. The decayed portions are inclined to droop; this is especially true in cases of rapid invasions, for at such times the parts do not dry so fast as the parasite advances. The rapid decay also prevents the edges of the leaflets from curling, although this takes place when the air becomes warm and dry.

"The distribution of colors over the affected leaf is very suggestive.

Under normal conditions, the unaffected parts retain a deep green color, while the diseased area may be yellowish-brown, dark brown or nearly black. But whatever the color, each area is sharply outlined. There is no gradual merging of one into the other, but a distinct change of color marks the progress of the disease. Occasionally another peculiarity may be noticed. If the leaves are closely examined it will be found that the green and the brown areas are not directly in contact with each other; they are separated by a narrow strip in which the green has been destroyed, and the brown has not yet appeared. It consists of a colorless or at most a very pale yellow line in which the growth of the fungus is probably very active. But during periods which are unfavorable to the development of the parasite this line cannot be discerned, and the green and brown tissues are apparently in contact. Under such circumstances the identification of the disease without the aid of the microscope is an exceedingly difficult matter. Let us suppose that the fungus has succeeded in gaining an entrance, and that it has advanced a limited distance in the leaf tissues. If at this time the weather should turn dry and hot, the development of the parasites would be checked, and the result would be the formation of a small brown spot or area, perhaps near the edge of the leaflet, and if several such spots exist the injury might be ascribed, without careful examination, to what is commonly known as the early blight fungus.

"The name 'downy mildew' has been given to the potato rot disease from the fact that there appears, under favorable circumstances, a downy or mouldy growth upon the under surface of the leaves. This is white in color and may be of considerable density. The upper surface of the foliage does not show it, but whenever this frost-like growth appears on the under side, it is almost certain that the potato rot fungus is present, especially if the other conditions mentioned above are also present. This external growth consists of spores and of the parts bearing them. The spores, or conidia, ma ture very quickly, and have the power of immediately propagating the fungus. They are small and light, and may be carried long distances by winds. It is largely owing to those bodies that the progress of this potato disease is so rapid. They are produced in countlessnumbers and are very energetic in attacking healthy tissue. It appears to be very probable, also, that these conidia, or summer spores, are the cause of the rotting of the tubers. After maturing upon the leaf, some fall to the ground and by means of water and other mechanical agents they are brought in contact with the tubers growing underneath the surface of the soil. Here they germinate and effect an entrance in the same manner as occurs above ground. The color of the affected tubers also changes to a brown, dry rot taking the place of the normal white color. The more slowly the tubers decay,

the less is the amount of moisture present; the contrary is also true. The decay does not take place in a uniform manner, but its progress varies in different tubers. In some it is mostly the parts near the surface that are affected, while in others the disease may advance rapidly towards the center of the tuber, causing the exterior to show a much smaller amount of disease than is actually present. The discoloration, however, generally presents a uniform appearance. Although it is by no means impossible for the mycelium to reach the tubers from the leaves by means of the stems, still it is the generally accepted opinion that infection does not take place in this manner. This belief was held many years ago, for in some of the earlier writings, recommendations may be found in which very high hilling is advocated so that the spores may be washed past the tubers and away from them, and not through the soil directly to them.

"There is still another feature of the late blight which it is well to bear in mind. The disease generally appears during August and September, although earlier and later attacks are not very rare. Coming so late in the season, all the earlier varieties are comparatively free from attack, but the latter ones are especially subject to the disease. This, however, is not necessarily due to the foliage of such varieties being more susceptible, but rather to the habits of the fungus. I have not observed that the age of the potato plants has a marked influence upon the spread of the disease; nor that the young foliage of the plants is less subject to the disease. It appears as if the parasite is able to thrive upon all potato foliage which is in a healthy condition at the time of the germination of the spores, and that old and young foliage or plants suffer practically to an equal extent. 'Acceptable evidence of a resting stage, or oosporic form of this fungus is lacking, and many believe that the fungus threads survive the winter in the partially diseased tubers.'

"The important question and the question which concerns every potato raiser is, 'Is there any practical remedy or preventive for the potato blight?' Fortunately there is, and there is no more reason now for a farmer to permit his potatoes to be destroyed by the blight than to permit them to be destroyed by the potato-beetle. The standard preventive is the Bordeaux mixture. This, if properly made and properly applied, will protect potatoes from the late blight and the consequent potato rot.

"Making the Bordeaux Mixture.—No doubt failure to secure satisfactory results from the use of Bordeaux mixture is often due to the fact that the mixture is not properly prepared. While its preparation is very simple it is possible the very simplicity has caused some to think no great care need be exercised in its preparation. This is a mistake, for the success of the application depends upon its being made properly.

The standard formula for Bordeaux mixture is:

Copper sulfate (pounds),	6
Lime (pounds),	4
Water (gallons),	45

"Potatoes will require from two to six barrels of the mixture per acre according to the size of the vines. In case a large area is to be sprayed it may be well to make up a stock solution of copper sulfate. The following directions for making up the solution may be found helpful. Into a barrel containing forty gallons of water suspend in a bag or gunny sack forty pounds of copper sulfate or blue vitriol. It is important that this be suspended near the surface as the solution has a greater specific gravity than water. If it should be put in the bottom of the barrel a saturated solution would soon be formed there, when no more of the copper would be dissolved. If the barrel be covered tightly this stock solution will keep for an indefinite length of time.

"The lime used should be fresh burned, caustic and not air-slaked. The most convenient receptacle in which to slake the lime is a somewhat shallow, long, water-tight box. To make up, say four barrels of the Bordeaux mixture, put into this box sixteen pounds of lime and add sufficient water to thoroughly slake. The lime should be kept well stirred during slaking that the water may come in contact with all parts. If it is desired to keep the lime for some days after slaking, it may be simply covered over with water so that the air will be excluded. When it is desired to use it, stir thoroughly and put one-fourth the contents of the box into a keg or other receptacle and dilute with twenty gallons of water. If more than four barrels of Bordeaux mixture are likely to be wanted, two slaking boxes would better be provided so that the lime will be ready for use when required.

"Into the barrel from which it is to be pumped, put six gallons of the contents of the barrel containing the dissolved copper sulfate. It seems hardly necessary to state that before doing this the copper sulfate solution should be thoroughly stirred. Fill the spray barrel half full of water and add the lime which has been diluted with twenty gallons of water. All of this material should be run through a sieve or strainer so that no sediment will clog the action of the pump.

"If Paris green is to be used to kill the potato 'bugs' put it in the mixture at this time, four ounces if the grubs are small, six ounces if they are half grown. A paste should be made of the Paris green by mixing it with a small amount of water before putting it in the spray barrel. Fill the barrel with water and the Bordeaux mixture is ready for use to protect potatoes from the flea-beetles, the blight and

the Colorado potato-beetles. A strong force pump is best, as then every part of the foliage can be covered by the liquid. During the operation of spraying the liquid should be frequently stirred, otherwise the ingredients will not be evenly distributed through the mixture."

Having given the Cornell suggestions, based upon success that must be rated as unusually high, I cannot serve the grower better than to couple with it the suggestions of Prof. W. J. Green, of the Ohio Station, who has given potato culture many years of scientific study. In Bulletin No. 76 he says:

"It has been our custom to make four or five applications of Bordeaux mixture to the potato tops each season, including Paris green, to destroy the 'bugs.' In some cases this course has been satisfactory, but the results have been variable. Some seasons the sprayed plants have remained alive two weeks longer than the unsprayed, and the yield was considerably increased by the treatment, but at other times the spraying was of no apparent benefit. Our experience has been duplicated by many others, and spraying for the potato blight is practiced less than formerly. Professor A. D. Selby, Botanist of the Station, suggests that the discrepancies in results may be due to a confusion of ideas regarding the cause of potato blight. Some have confounded tip burn of the leaves, in dry hot weather, with blight. Others have mistaken the effect of drought for blight. It is probable, also, that a bacterial disease, not amenable to fungicides, has been the cause of much of the trouble.

"Where fungi alone are responsible for the dying of the potato tops, repeated experiments have shown that spraying with Bordeaux mixture is beneficial. Where the bacterial disease prevails it appears that insects are largely responsible for its spread, also that the malady may be carried into the field in diseased tubers. In this case prevention consists in using sound seed and in keeping the insects in check.

"The work of the experimenters does not appear to be finished, either along the lines of investigations concerning the causes of blight, or in the discovery of the best means of preventing it, but it is not wise for potato growers to give up trying to combat it. They could deal with it more intelligently and successfully if they knew whether to spray for fungi in the form of the 'early blight' or the 'late blight' or whether to be on their guard against a bacterial disease.

"Meanwhile the only safe plan is to guard all sides. If potatoes rot in the field before digging, and continue to rot in the cellar, the disease will most likely be transmitted to the succeeding crop. If they appear to be sound on the outside but when cut across the

stem end a dark ring is seen, the disease is present, and will appear in the crop grown from them.

"Since the bacterial disease may be spread by insects it is even more essential than has been supposed, that the Colorado beetles, flea beetles and blister beetles 'old fashioned potato bugs' be kept in check. Six ounces of Paris green to a barrel of Bordeaux mixture is the best preparation for this purpose. Paris green is less harmful to the plants in combination with Bordeaux mixture than alone. The blister beetles and flea beetles are not killed by the Paris green, but the Bordeaux mixture is repellant to them, and they do far less harm where it is used than where no application is made. Where the Colorado beetles are very numerous, hand picking is advisable.

"If sound potatoes are used for seed, blights due to fungi may appear, but the same remedies apply. In that case the Bordeaux mixture is more useful than if the bacterial disease alone is present. The poison needs to be used in all cases, for not only do the 'bugs' injure the plants but make openings for the entrance of spores of fungi. It is quite probable that not enough care is usually taken to destroy insects affecting potatoes, for, as above stated, they are harmful, both directly and indirectly, and unless strong efforts are directed against them, other preventive measures are likely to fail."

Profit from Spraying.—It is safe to say that a thorough application of Bordeaux mixture should be given potato vines when the flea beetle appears, and this spraying will have an indirect influence against early blight by preserving the vigor of the plants. It may come at such a time that it will be a direct preventive of an attack of this blight for a short period of time. Then the very practical question arises from the grower's decision: Will it be profitable to continue to make thorough sprayings until growth of new foliage ceases—five or more additional sprayings? It would be pleasant if one could say definitely that such a course would pay, as we like to engage in profitable work. But experience teaches that local conditions must control one's course. If he live in the lower part of the northern potato belt he has learned to have little fear of the late blight. In one year out of five he may suffer loss from it, and in some sections the chance of loss is very remote. But early blight is a cause of loss to him nearly every year. If he plants his crop early, the vines have filled the middles before time for an attack. If he were spraying, he would have made two applications of the mixture before this date to insure coating of the foliage before any germs developed, but several more applications must follow to keep all new and old growth covered, and it is difficult to do this work without injury to the vines, and the work is costly. If the season re-

main cool, the loss in unsprayed fields would be slight. If it be very hot and showery he should not expect with confidence immunity from partial attack of early blight, no matter how well he may have sprayed. It is an open question, and the grower should be governed by his variety planted, the probable market price and his past experience.

It is my personal experience that it is feasible to depend much upon the resistance certain varieties offer to attack of early blight. We now have a few varieties that will not blight seriously until a good crop has been made. When such are planted in a rich soil, and are given the best culture, the danger of loss is reduced to a minimum. If other varieties are planted, and the planting has not been done very early, it is usually best to give the protection afforded by thorough and repeated sprayings. Where late blight threatens, spraying is to be advised. This blight, followed by rot, is a serious menace to the crop in cool latitudes. The spraying will not be found a sure preventive unless it is very thorough, and the blight may not appear at all, but there is more reason for undertaking the work in sections threatened by it than in those subject only to attacks of early blight, which is difficult to ward off.

I have no desire to detract from the importance of Bordeaux mixture as a preventive of the blights. Its use must increase as disease increases. But in seeking to state facts as they appear to be, an effort is made to keep on safe ground, not urging heavy investment of labor and money upon all growers, but only upon those who cannot evade loss by selection of soil and varieties, and who reasonably should expect frequent loss if sprayings are not given. The practice of spraying potatoes will increase because disease will grow more virulent, and there is reason for believing that thorough repeated spraying will prove itself in time to be financially profitable to most growers. One or two sprayings before the tops fill the middles is always to be advised, as more vigor is insured.

Tip-Burn.—In addition to the early and the late blight, there is an appearance of blighting of potato vines often seen that is not attributable to a fungous disease at all, but is the result of the direct heat of the sun, usually in connection with drouth. It is called tip-burn, and we take from Bulletin 49 of the Vermont Station the following description:

"The disease we term 'tip-burn' is characterized by the death of the potato leaves at their tips and margins, which portions dry, blacken and roll up or break off. This trouble has occurred quite commonly in Vermont during the dry, hot weather of mid-summer in 1894 and 1895, and as before stated, it was observed to a worse degree in Michigan and Wisconsin where the drouth was more severe. In its earlier stages the dead tissues are often quite free from inva-

sion by fungi, and even in the advanced stages the fungi present are chiefly such as live upon dead plant tissue only.

"Tip-burn is not caused by the attacks of parasitic fungi. It is rather attributable to the unfavorable conditions surrounding the plant, especially to the dry hot weather with insufficient water supply. It is aggravated by any other conditions which tend to lower the general vigor of the plant, such as insufficient food supply, and attacks of insects and the early blight fungus. This difficulty has not been observed to any serious degree upon plants until after they pass the blossoming period, and naturally begin to weaken.

"As the older leaves weaken, especially the lower leaves of the plants, the tissues of the interior of the leaf sometimes develop dead spots surrounding flea beetle punctures or other injuries. These spots soon dry and show distinct rings and bear a general resemblance to the 'ringed spots' caused by Paris green and by the early blight fungus. They may occur, however, in the absence of both these causes. Dr. Sturgis, describing these spots in his Report for 1894, attributed them to the effects of dry, hot weather. We believe this to be the correct explanation and would therefore associate them with 'tip-burn' rather than with the true 'early blight.'

"Prevention.—Effort should be made to increase and sustain the general vigor of the plant by proper selection of varieties, preparation and cultivation of the soil, and protection against the attacks of insects and fungi. The only thing that can be done in addition is to irrigate in times of extreme drouth."

Potato Scab.—The unsightly appearance of many tubers is due to scab. This is a fungous disease with which most growers have opportunity of acquaintance. An immense amount of work has been done by our Stations in study of the disease and in attempts to prevent its ravages. Some years ago the scab was attributed by growers and investigators to a variety of agencies, such as stable manure, insects, lime, etc., but the Connecticut and North Dakota Stations demonstrated beyond chance of doubt that the injury to the tubers is produced by a fungus (*Oospora scabies*). The following statement, taken from Bulletin 19 of the North Dakota Station, states the facts concisely:

"Potato scab is due to the growth of a fungus upon the young potato tubers while they are developing in the ground. The disease is communicated to the new crop by way of the seed tubers, or by way of the soil or old potato tops, if the potatoes are planted upon old ground, the germs having remained over from previous crop. If an old potato patch is in the near neighborhood the disease may also be communicated by wash water, or, perhaps, through dust blown from the old patch. If, however, there are no disease-bearing

tubers planted, and the ground used is ground that has never been used for potatoes, and care is taken that refuse from a previous disease-bearing crop does not reach the soil of the new crop, one may expect it to be free from the disease.

"Since the parasite is microscopic, one cannot be sure that there are no spores of the disease on the seed potatoes, though they appear to be smooth."

Control of Scab.—Growers have observed that an application of fresh stable manure, lime, wood-ashes and similar material very often gives a scabby crop, and this is due to the favoring effect of these substances upon development of the scab fungus. They can not produce the disease, but they may put the soil into such condition that the scab germs in it multiply and thrive. On the other hand there are materials that either destroy the germs or else create such soil conditions that the germs do not grow. The results of Station tests are very numerous and very conflicting, but the conflict is largely due to the variation in soil conditions, and it is now possible to make an accurate statement of some of the truth about the control of this disease.

Treatment of Seed.—The germs of the fungus may be on the seed to be planted, and not in the soil at all. When this is the case, a fair degree of control of the disease may be obtained by the treatment of the seed with a fungicide. Probably there is none superior to corrosive sublimate. Under this head I quote Professor Green, of the Ohio Station, Bulletin No. 76:

"The usual recommendation for the treatment of seed potatoes is to soak the seed for one and one-half hours in a solution of corrosive sublimate, two ounces to thirteen gallons of water. This treatment is efficient, but so long an exposure to the solution reduces the vitality of the potatoes somewhat, varying with the variety and condition of the seed. The matter of time at the busy season of the year is of considerable importance, and this feature alone often prevents the use of the treatment. For two seasons we have been soaking the seed one hour only, and find the result to be entirely satisfactory Some experiments conducted last season indicates that the length of time may be still further reduced, without detracting from the value of the treatment.

"Complaint has been heard that treated seed, if kept several weeks before planting, loses its vitality. This may be true if the seed be stored in tight boxes or barrels, without drying, but we have kept treated seed in crates for several weeks without injury, although in a cold storage room, where the risk would be less than in a higher temperature."

Later experiments have shown that forty-five minutes is a sufficient length of time. In my own experience a convenient method

of treatment is to use water barrels, setting them on boxes on the ground where potatoes are to be spread for drying. When a barrel has been filled with potatoes, the solution is poured on, and at end of treatment it is drawn off in buckets and poured into another barrel of potatoes while the treated barrel is overturned on the ground. This is speedier than bagging the potatoes and immersing them in barrels of the solution, but the latter way may be made slightly less laborious.

Scab in the Soil.—When the scab fungus is in the soil, as is very frequently the case in old potato sections, there is no treatment of the seed that will insure a clean crop, but the effects of the disease may be controlled in degrees varying with the character of the soil. In the first flush of success with the corrosive sublimate treatment of seed, the claim was made that fertilizers and soils exercised no influence upon the development of the disease, but this is an error. Seed potatoes that are suspected of any contamination with scab should be given treatment to kill the germs upon them, and such seed planted in infested soil will give a cleaner crop than untreated seed will give, but still the product may be unmerchantable if the soil conditions favor the multiplication of the germs already in it. Success in the fight against potato scab must depend in part upon a control of soil conditions that will bring the destruction of the germs already in it.

It was once held that the rational means of cleaning an infested soil consisted in crop rotation, and such rotation is an aid, but we now know that the germs live in a soil six or more years without a potato or beet crop to feed upon. It is probable that the improvement resulting from ceasing to grow potatoes in an infested soil for five or six years is not caused by any "starving out" of the germs through absence of potatoes as hosts for this fungus, but is due to a change in soil conditions caused by some intervening crops.

"Souring" the Soil.—My attention was called urgently to this matter seven years ago when one potato field in the farm had become so full of the scab fungus that the crop was unmarketable. There had been increase in scabbiness for a term of years. A farmer made the statement in my presence that he never failed to grow a potato crop free from scab when planting in land that had had a winter cover crop of rye. For seven years the experiment has been made of growing a crop of potatoes in this field on a sod of fall-sown rye, and the results have been very interesting in several ways. Incidentally I may say that the yield this season of the seventh successive crop of potatoes was 285 bushels per acre, and during these years little had been done to aid the rye in maintaining fertility except to apply phosphoric acid in form of an acid phosphate. But the experiment was conducted in part to determine something about the control of scab in the soil. The seed was left untreated, and

the first crop taken off the rye sod was merchantable, though somewhat scabby. The next year the potatoes were more nearly clear of the disease, and in the third year the appearance of the tubers was excellent. Some traces of disease remained, but the extent of its presence was immaterial from the standpoint of a grower. I emphasize the fact, however, that I used varieties most resistant of scab.

This rye was plowed down each spring in the first hot days when the growth was about one foot high, and acid was produced by its decay. Experiments at the Rhode Island Station were showing clearly that the scab fungus delighted in an alkaline soil, or one treated with lime, and that it made little development in an acid soil. The natural inference was made that a growth of rye plowed down in warm weather would cause the formation of sufficient acid to prevent the growth of scab, and this remains true for some soils, but not for all. Some land is neutral or slightly acid, as shown by the litmus paper test, and any body of green vegetation rotting in it would produce a decidedly acid condition, unfavorable to the scab fungus. In the case of such soil it appears feasible to destroy the fungus by producing acidity in it by green manuring.

Other land is alkaline, and, if it is so in marked degree, a green crop rotting in it would not produce any excess of acid. Farmers are aware that some land may be "soured" to the point of unproductiveness by green manuring in midsummer while other land will not become "sour" through the practice. Likewise may land infested by the scab fungus be made sufficiently acid through the plowing down of a coat of green stuff in the spring to prevent much development of the fungus, while other land, strongly alkaline, would not be rendered acid and unfriendly to the fungus in this way.

Lime corrects soil acidity and thus promotes development of this disease. It is unwise to use lime on land immediately preceding a potato crop, provided there are any scab germs in the soil or on the seed, and the same is true of fresh stable manure.

Sulphur for Scab.—The New Jersey Station obtained some striking results from the use of sulphur on the land at the rate of 300 pounds per acre in the row, the seed being treated with it also. A series of experiments indicated that a sovereign remedy had been found, but tests elsewhere brought out the fact that soil conditions are a prominent factor, and that while the sulphur, like a green crop plowed down, would check the fungus in some soils, it was only slightly effective in other soils.

Some Station Conclusions.—From special Bulletin "S" of the New Jersey Station I take the following:

"In soil known to be thoroughly infested with the germs causing

potato scab, the fungicidal properties of a considerable number of substances have been tested during the past six years.

"Lime, gas-lime, kainit, corrosive sublimate, sulphur, Bordeaux, cupram, oxalic acid, sulphate and sulphide of ammonium, bi-sulphide of carbon, sulphuric acid, kerosene, formalin, creolin and benzine have each been added to the soil, and nearly all have had no effect upon the scab. A few reduced the disease somewhat, as corrosive sublimate, Bordeaux and cupram, but not enough to render them of practical value. Lime increased the percentage of scab.

"Of the whole list, sulphur only has yielded results which warrant it being recommended to potato-growers as a preventive of scab. It is not uniformly active, depending, probably, upon the conditions of soil temperature and moisture.

"For practical use, 300 pounds applied to the open row are deemed sufficient. It is also best to roll in sulphur the freshly-cut 'seed,' as it prevents rapid drying out of the water.

"The soaking of scabbed potatoes in corrosive sublimate has not proved of much practical value when they were planted under the conditions of the experiment, namely, in badly scab-infested soil.

"Uninfested soil may be readily contaminated by the introduction of scabbed potatoes or beets. The germ of potato scab, while not readily destroyed by boiling, seems to be largely destroyed by passing through the digestive tract of cattle. Special exposure (ridging) of scab-infested soil to the elements during the winter months does not appreciably affect the vitality of the disease. Susceptibility to scab is greater in some varieties of potatoes than in others.

"No plants, save the potato and beet (and probably the radish and turnip), have been found subject to root scab. All attempts to inoculate various species, both wild and cultivated, many of them closely related to the above-named hosts, have proved unsuccessful.

"Experiments have demonstrated that the scab fungus is actively retained in the soil for at least six years without the presence of potatoes or beets."

In connection with the above, I ask that a close reading be given the following summary of Bulletin No. 40, of the Rhode Island Station, believing that the results stated make plain much truth about this fungous disease:

"The results from the use of sodium compounds and oxalic acid in connection with barnyard manure confirm those obtained in 1895, viz., common salt (sodium chlorid) tends to lessen the amount of scab. Soda ash (sodium carbonate) tends to increase the scab. Oxalic acid tends to lessen the scab when used with barnyard manure only or when common salt or soda ash is present.

"2. A scabless product was produced where calcium chlorid or land

plaster (gypsum) was used. Calcium chlorid had a marked poisonous effect upon the potato plants and nearly destroyed them. Land plaster appeared not to have increased, and it may have lessened, the yield slightly. Where calcium at the same rate as in the calcium chlorid and land plaster was applied to the form of wood ashes, air-slacked lime, calcium carbonate, calcium oxalate and calcium acetate, the vigor of the plants and the yield of tubers were wonderfully increased, but the crop was so badly scabbed as to be worthless.

"3. Where the fertilizer was used without any lime compounds no scab resulted, showing that the acid soil must have rendered dormant or destroyed the scab fungus introduced on the scabbed seed tubers of the two previous years.

"4. The treatment of the seed tubers with a 1 to 1,000 solution of corrosive sublimate for one and one-half hours was utterly useless where the soil was favorable to the disease and where it was already badly contaminated by two preceding lots of scabbed seed tubers and scabbed crops. In other experiments by us heretofore where the soil was favorable to the disease, but where little or no contamination already existed, Bolley's corrosive sublimate treatment proved highly effective. It is probable that some germs escape even this treatment, but fewer, of course, where the seed tubers are not scabbed, so that there is danger if potatoes and root crops are grown frequently that serious contamination may nevertheless result eventually. The necessity, on land intended for potato growing, of avoiding the frequent use of fertilizers which tend to make the soil more favorable to the development of the scab fungus is therefore obvious.

"5. The materials which favor the scab and which are at times applied to land are: Stable manure of all kinds, wood ashes, air-slacked or caustic lime and carbonate of soda (soda ash), potash, lime and magnesia.

"6. The materials which do not tend to make the scab and which may decrease it, are most commercial fertilizers, seaweed, potash salts (excepting potassium carbonate), land plaster, common salt and ammonium sulfate. Sodium nitrate (Chili saltpeter), if used in large quantities, may favor the scab eventually, but from the amounts usually applied no serious results would be expected to follow. In case a soil were badly contaminated and favorable to the disease, super-phosphate, ammonium sulfate, kainit, sulfate and muriate of potash are materials which, applied as fertilizers, would tend gradually to alleviate the conditions.

"7. Sulfur when mixed thoroughly with the upper seven to eight inches of a badly contaminated soil favorable to the disease, though checking the scab somewhat, was practically useless.

"8. The treatment of seed tubers by rolling in sulphur and sprinkling the balance in the row at the rate of 300 pounds per acre is claimed by Halsted to be quite effective. The use of the very poisonous corrosive sublimate solution would be thereby avoided, yet the additional expense of the sulfur over the corrosive sublimate treatment for this purpose militates against its use in that way where potatoes are grown at the present low prices.

"9. The marked acidity (sourness) of soils, or the absence of carbonates in them, seems to indicate their ability to produce a scabless product even when untreated seed tubers are used."

OUR CONCLUSIONS.

When danger of scab threatens, all seed should be treated with corrosive sublimate or Bordeaux mixture before planting, and the land should not be given an application of fresh stable manure or lime within a year of planting. Rotation of crops is desirable. If the soil is infested with the fungus, an attempt should be made to produce some acid in it by plowing down a green crop, like rye, in the spring. Lime should not be applied. Rolling the cut seed in sulphur before planting and applying 300 pounds of sulphur in the row, may give good results. Some varieties of potatoes are much more subject to injury from this fungus than others are. Select resistant varieties.

On the other hand continuous planting of potatoes and the use of manure will not bring scabby crops if the fungus germs are not present, or if they are kept in control by the acidity of the soil. Clean seed, made so by treatment of good tubers with the solution of corrosive sublimate, and selection of resistant varieties do much to save from loss. Drainage is an aid, in that it removes a surplus of moisture. Experiments with irrigation of potatoes indicate that water favors scab development, and in our own experience the disease is worse in wet seasons than in dry ones. Early digging is advisable when scab is present. While most scientists regard the worst roughening of the skin as an effort of nature to heal the injury made by the fungus, yet there is evidence that the injury continues after maturing of the tubers when left in the ground. Exposure to light checks its work. The budding of seed in the sunlight before planting destroys the vitality of the germs.

Rhizoctonia.—A disease that is new to potato-growers in this country is appearing in fields in many States. In the annual report of the New York Station for 1900, attention is called to it, and we learn that it was observed over ten years ago in Iowa. In 1900 I found the disease in one of my fields, losing two-thirds of the crop by its ravages, and learn from our Station workers that it is the soil

fungus, rhizoctonia, which attacks the roots and stems of many cultivated plants. The first indication of its presence is found in the wilting of the leaves in the buds. The edges turn inward, giving the plant a lighter appearance. The wilt continues, and examination of the stem shows discoloration. The presence of the fungus in the stem appears to shut off the circulation of the sap, and in bad cases the vine will turn yellow quickly. In other cases, the injury to the stem may be sufficient only to dwarf the growth of the vine. The fungus may attack the stems that feed the tubers, checking their growth and giving only small potatoes from large vines. In 1902 this disease again attacked a field of potatoes on the farm and gave promise of most severe injury, but it was checked by some unknown means—most probably by a period of cool, dry weather—and while some plants were too badly affected to recover, a majority did so, losing the wilted appearance and giving a good yield of large tubers. It is known that the germs are transmitted on the seed, and that when they are in the soil it may remain infested for many years. Station authorities advise treatment of the seed with corrosive sublimate and liming of the land. The spraying of affected vines with any fungicide can not affect the disease which is lodged inside the stem of the plant.

HARVESTING AND STORING.

Potatoes keep best when they can be left in the ground until the cool nights of September, if the season is dry. In a very wet season, ripe potatoes left in the ground may make a second-growth, sending up sprouts from the eyes, and there is danger also of rot. But it is not easy to keep potatoes stored in quantity in very hot weather, and it usually is better not to dig until early in the fall unless the crop can be marketed at once. Just as soon as the nights become cool, the potatoes can be stored safely in piles in the field under a covering of straw, or in cellars. Any tubers cut by steel in digging should be taken out of a lot intended for early storage as they will rot in a warm splace. This is equally true of potatoes for early shipment to a distant market.

Diggers.—Formerly the crop was dug largely with hoes, hooks and forks, but the lack of cheap labor has brought a number of kinds of good implements for harvesting the crop. In loose soils, and especially with shallow planting and ridge culture, some of these diggers do nearly perfect work. The best digger is one that lifts up all the soil in the row with the potatoes, sifts the soil back into the furrow it makes, and leaves all the tubers lying on the surface. The digger that elevates the mass of earth in the row, and gives

time for thorough sifting before the potatoes are dropped upon the ground, does the best work, but it is, of course, at the expense of extra power. Such diggers are expensive, but in loose soils they soon repay their cost. There are cheaper diggers that do excellent work under favorable circumstances. In the selection of a digger the matter is one of arithmetic largely. The cheaper the price, the fewer facilities it has for sifting the soil away from the tubers, as a rule, and one must be governed by the acreage he has to harvest, and the market price of potatoes and of human labor.

For heavy soils in which potatoes are planted deep, it is not possible to have a digger that will be easy on horses, and yet do satisfactorily clean work. There is a large volume of soil to be moved by the digger, and there is difficulty in securing a perfect separation of the potatoes from the soil. It is not our purpose to call attention to the merits and demerits of any of the diggers now on the market, but to remind growers that soils and methods of planting and of culture vary so much that no investment should be made without a field trial. Clean work should be made a leading consideration, as we want to secure what we have produced, but the power required and the wearing qualities of the emplement should be taken into account.

Potato Boxes.—In great potato-growing sections years ago it was a common practice to pour bulk potatoes into wagon-beds, and to shovel them out into baskets when unloading. This primitive method was laborious, and did injury by bruising the tubers. Potato boxes have now come into common use in many districts. They are made of light material, preferably bass-wood, or similar wood. The boards for sides and bottom should be three-eighth inches in thickness, and the ends one-half. The size of box should be such that it will contain 2,688 cubic inches, level full. The legal bushel measure for grain contains 2,150.4 cubic inches, and in measuring roots or potatoes the rule is to heap the half-bushel measure sufficiently to add one level peck to the two level half-bushels. Five level pecks, or 2,688 cubic inches, are the equivalent of two rounding half-bushels, and of a level potato box rightly made. The following dimensions are the ones used by a leading manufacturer of these boxes: Twelve and one-half inches deep, thirteen and one-half inches wide and sixteen inches long. This gives exactly 2,700 cubic inches. This size probably is more convenient than any other that could be devised. The length of two boxes is near the width of the ordinary wagon-bed, leaving only room for the hands when putting them into position, and, when empty, one box can be placed inside of two others, economizing space. With high side-boards on the wagon-bed it is convenient to tier up sixty bushels when drawing from the field to the cellar, or to market, but the extensive grower may prefer

a long platform that will hold twenty or more boxes in a single tier.

The home-made box is usually less satisfactory. It is made rarely of the best light material, and when one takes into account the number of times the boxes must be handled, he may see the advantage of having the very best. Manufacturers furnish solid boxes that weigh only seven pounds, are exact in size, trim in appearance, and will last for fifteen or twenty years, if cared for properly. Other boxes, slatted on ends and sides, are furnished at a less price, and are less substantial. The boxes, bought in crates of a dozen, cost about eighteen cents a piece for the solid ones and fourteen cents for the slatted.

The potatoes are picked up after the digger and placed into the boxes, the unmerchantable tubers being left on the ground. When a load is ready, the boxes are handed up to the driver of the wagon, and while he takes the load to the car, cellar or other place of storage, another load is made ready by the pickers. Returning, the driver puts his empty boxes out, takes on his load of full ones, and the work proceeds with a minimum amount of handling. If the potatoes are drawn directly to consumers, neat boxes for handling them are a good advertisement as well as a means of saving labor, time and injury to the stock.

When good seed, cut to two eyes, has been planted in good ground, and the tillage has been right, the number of unmarketable potatoes usually is small, and many years we do not pick them up. It is the practice of some growers to pick up all sizes together and then to sort out those that are not merchantable, using the best of these for planting and the remainder for stock feed. As has been said in another place, the small tubers are not the most desirable for use as seed. If there is a considerable proportion of the crop that is too small for market, it should be gathered from the ground after the merchantable potatoes have been taken up.

Storing Potatoes.—Winter storage should not be provided until the weather is cool. If the potatoes are put into large bulk in cellars, pits, or piles on the ground in hot weather, they will sprout quickly in a warm winter. In the case of seed potatoes, I have found it well to store temporarily in cellar in the fall, moving them outside for burying when the weather is cold. A good plan is to scatter some straw over the ground intended for their burying, and then wait for a freeze. Remove the straw when the temperature is above freezing, and put the potatoes into narrow ricks on the unfrozen ground. Cover to a depth of six inches with dry straw, and then put on six inches of earth. This covering of soil will freeze quickly in cold weather, and then another covering of straw should be added, and on this soil manure or corn-stover may be placed. With this method, the potatoes are cool when buried and the ice in the under

covering of earth is held in it throughout the winter, giving a very good and cheap cold storage until time for early planting. Farther north, the more complete protection by pits is desirable. Storage of seed in ordinary cellars does not give good results in warm winters. A cold-storage building may be provided, having warm walls, and good means for ventilation in cool nights of spring and for exclusion of the warm air of mid-day, and potatoes may be kept unsprouted thus without any ice until quite late in the spring. Make the walls double, with dead-air space between them, have the floor proof against rats and water, and admit the cool air through chutes under the bins, letting the warm air pass out through a ventilator. When the room has been filled with cold air, close tightly. The temperature should not be permitted to drop below thirty-five degrees Fahrenheit for any great length of time. That is near enough the freezing point for safety. Chilled seed is as unsafe for planting as heated seed, and either invite loss and disappointment. Darkness is essential to the proper keeping of potatoes for seed or eating.

Shrinkage in Storage.—Potatoes lose in weight rapidly for a few days after the digging, either when left in boxes or put into piles in field or cellar. The greatest product is gotten by immediate marketing. After the sweating they undergo in the bin or pile, the loss is not great until a tendency to sprout manifests itself. Then shrinkage occurs either through the sprouting or the stirring given to prevent sprouting. The amount of shrinkage is so dependent upon variety and kind of storage that no figures of special value can be given. Roughly speaking, the shrinkage in cellars from storing time until spring is eight to fifteen per cent. In cold pits it may be less. In warm cellars the loss, including normal decay of cut or bruised tubers, sometimes exceeds fifteen per cent. by the first of May.

POTATOES AS FOOD.

Professor Storer, in his valuable work on Agriculture, remarks that "it has been said that the famines which formerly devastated Europe became much less frequent after the potato was cultivated as a field crop. Before the introduction of the potato it happened constantly, every six or eight years, that somewhere on the continent of Europe the inhabitants of large tracts of land suffered from dearth because their grain crops had failed."

According to Dr. Langworthy, the potato is probably a native of Chile, being introduced into Europe between 1580 and 1585, and into our country about the same time. Its food value was quickly appreciated, and it is a staple article of diet. From the year-book of the

Department of Agriculture, I quote the following, by Dr. Langworthy, of the Office of Experiment Stations:

"Cooking of Potatoes.—Although the potato owes its nutritive value principally to carbo-hydrates, it will be remembered that it contains some nitrogenous matter also. According to the investigations of Lawes and Gilbert, the juice of the potato contains more proteid or albuminoid nitrogen than the flesh. This is an important matter, since albuminoid nitrogen is more valuable for the body than non-albuminoid nitrogen. In general, it may be said that 85 per cent. of both protein and mineral matter in the potato (the latter being valuable for dietetic reasons, though not a nutrient) is in the juice. More or less of the juice of any food may be accidentally lost when it is prepared for the table; and the possibility of loss in cooking, due to this and other factors, is a matter of importance. Any sugar or other soluble carbo-hydrates might be removed if potatoes were cooked by boiling. No considerable loss of starch as such is to be expected, since starch is insoluble in water. Some starch is changed to a soluble body, dextrin, a sort of sugar, by the action of dry heat, possibly also when water is present.

"The principal ways of cooking potatoes are baking, boiling and frying, or some modifications of these processes. The objects sought are principally to soften the tissues and render them more susceptible to the action of the digestive juices and to improve the flavor. Just why cooking changes the flavor, as it does, has apparently never been made the subject of investigation. In potatoes, as in other foods, the cooked starch is more agreeable to the taste than the raw. Possibly also there are volatile bodies of more or less pronounced flavor, which are removed or produced by the heat of cooking. The physical condition of the potato is much affected by heat. In the raw potato the separate starch grains are inclosed in cells with walls composed of crude fiber, a material resistant to digestive juices. If potatoes were eaten raw, the digestive juices would not reach the starch as easily unless the cell walls happened to be ruptured mechanically, as in mastication. Heat, however, expands the water present, ruptures the cells, and breaks up the starch, expanding the granules, which, when raw, consist of tightly-packed concentric layers, to a mass of much less solid structure.

"The albuminoids in foods are coagulated by heat, and so are rendered insoluble in water in which food is cooked. This explains why foods, meat especially, should be plunged into boiling water if it is desired to retain the albuminoids. The heat at once coagulates the albumen on the surface, thus preventing more or less completely the extraction of materials in the inner portion. It seems probable that this reasoning would apply to potatoes as well as to meat, although they contain much less albumen. The effects of cooking po-

tatoes by boiling in different ways were tested not long ago at the Minnesota and the Connecticut (Storrs) Agricultural Experiment Stations. The potatoes were boiled in distilled water, limewater, and alkaline water; part were boiled in water hot at the start and part in water, cold at the start. In some cases the potatoes were peeled before boiling and in some cases this was not done. In two tests the peeled potatoes were soaked before boiling. The total loss of material (dry matter) ranged from 6.5 per cent. of the total amount present in the case of the peeled potatoes soaked before boiling to 0.2 or 0.3 per cent. in the case of the potatoes boiled with the skins on. The greatest loss of total nitrogen and ash were also found when the peeled potatoes were soaked before boiling; least when this was not done. Whatever the method of boiling, little of the carbohydrates was lost. From the experiments as a whole, it may be said that when potatoes are boiled with the skins removed there is a very considerable loss, not only of organic nutrients, but also of mineral salts. To obtain the highest food value, potatoes should not be peeled before cooking. When potatoes are peeled before cooking and placed directly in hot water and boiled rapidly, less loss of materials is sustained than when they are cooked in water cold at the start. If potatoes are peeled and soaked in cold water before boiling, the loss of nutrients is quite considerable; in the case of proteids, being equal to one-fourth of the amonnt present. The loss in a bushel of potatoes thus cooked would be equivalent to the albumen in a pound of sirloin steak. When potatoes are boiled with the skins removed the greatest actual loss of nutrient seems to be due to the mechanical abrasion of some of the soft outer portions while cooking. In the experiments at the Connecticut (Storrs) Agricultural Experiment Station it was found that nearly three per cent. of the carbo-hydrates and four per cent. of the albuminoid material were lost when potatoes were thus cooked. When the potatoes were boiled with the skins on, the loss of nutrients was very slight, consisting chiefly of non-albuminoid nitrogenous substances and mineral matter. It is, therefore, evident, if it is desired to boil potatoes with as little loss as possible, that the skins should be left on.

"Comparatively speaking, there are probably few cases in which it is necessary to take account of the losses due to different methods of boiling potatoes and where the possibility of loss would outweigh the liking for them prepared in some particular way; but in institutions where a large number must be provided for, and, in fact, under any condition where rigid economy is necessary, the matter may assume considerable importance.

"An extended study of the relative composition of large, medium, and small potatoes, and of the different parts of the tubers and of the taste and culinary properties, was recently reported by Coudon

and Boussard, two French scientists. The authors believe that the culinary value of potatoes is directly proportional to their nitrogen content and inversely proportional to their starch content. The different varieties of potatoes were found to vary greatly in their resistance to boiling, some retaining their form completely, while others were almost wholly disintegrated. The opinion was advanced that resistance to boiling depends principally upon the relative amount of albuminoids present. No definite relation was observed between chemical composition and early maturity. Generally speaking, the early varieties contained more water and nitrogenous materials and less starch than the late varieties tested.

"As regards chemical composition, it may be said in general that boiled potatoes contain a little less water than raw potatoes, and except as this changes somewhat the proportion of nutrients, they differ little in composition from the raw. Mashed potatoes, if they are not seasoned, must necessarily have the composition of the unmashed boiled potato, making allowance for the small proportion of water which would probably be lost by evaporation in mashing. When milk, cream or butter is added to mashed potatoes in preparing them for the table, the nutritive value is increased, though the chief reason for adding such materials is doubtless to improve the flavor. This is also the reason why salt and pepper are added. Baked potatoes have practically the same composition as the uncooked, some water being lost by evaporation. When potatoes are fried, as in making potato chips, they lose by evaporation much of the water present and absorb more or less fat. They, therefore, have a higher nutritive value, pound for pound, than raw potatoes. Potato chips have been found, by analysis, to contain two per cent. water and 39.8 per cent. fat, as compared with 78 per cent. water and 0.1 per cent. fat when raw. The many ways of cooking potatoes, with or without the addition of other materials, which are described in books devoted to cookery, are, in principle, modifications of those already alluded to. The wholesomeness of potatoes cooked in different ways is largely a matter which each must decide for himself, the general experience being that for men in health most of the methods followed are satisfactory.

"Evaporated potatoes are now on the market, being especially recommended for provisioning camps and expeditions. As compared with fresh, the evaporated potatoes have a high nutritive value in proportion to their bulk. This is the case with all evaporated foods, such material having been concentrated by the removal of a large proportion of the water originally present."

Potatoes for Live Stock.—Many experiments have been conducted to determine the value of potatoes for feeding to farm animals. It is found that they have a value as an aid in digestion of dry feeds

that may exceed their own actual food value. The potato is largely water, and in the feeding of thousands of bushels to horses, cattle and sheep, we have been led to believe that a bushel of corn at forty cents is as cheap feed as potatoes at ten cents, excepting such small amount as may be needed to aid digestion. Experience and Station experiments indicate that potatoes should be cooked for hogs and poultry, but that they may be fed raw with profit to horses, cattle and sheep.